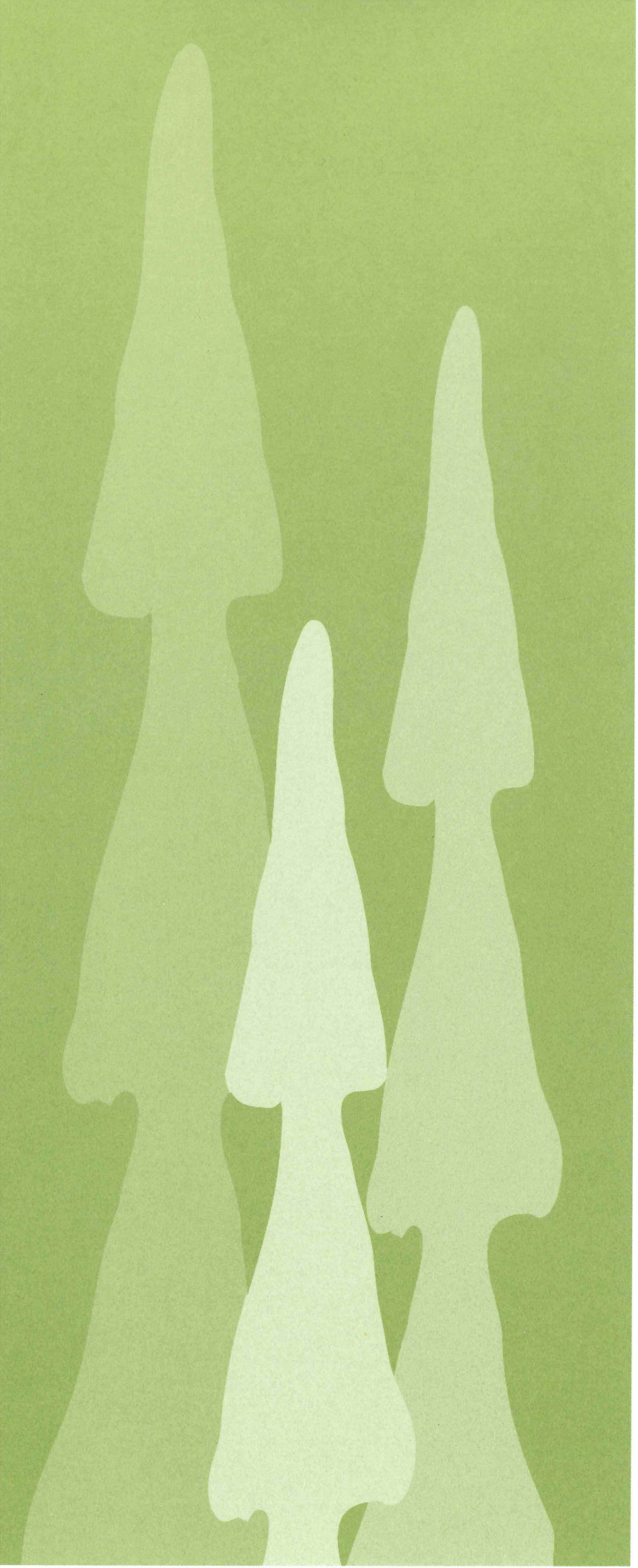

GENERIC ENVIRONMENTAL IMPACT
STATEMENT ON ANIMAL AGRICULTURE

A Summary of the Literature

Related to the Social, Environmental, Economic and Health Effects

VOLUME 1

Prepared for the
Minnesota Environmental Quality Board
by the
University of Minnesota

ENVIRONMENTAL
QUALITY BOARD

SEPTEMBER 1999

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To Interested Minnesotans:

The GEIS on Animal Agriculture is a statewide study authorized and funded by the 1998 Minnesota Legislature and ordered by the EQB. The Legislature directs the EQB to "...examine the long-term effects of the livestock industry as it exists and as it is changing on the economy, environment and way of life of Minnesota and its citizens."

The intent of the GEIS is twofold: 1) to provide balanced, objective information on the effects of animal agriculture to future policymakers; and 2) to provide recommendations on future options for animal agriculture in the state. The success of the GEIS on Animal Agriculture will be measured by how well it educates and informs government officials, project proposers, and the public on animal agriculture, and the extent to which the information is reflected in future decisions and policy initiatives, made or enacted by Minnesota state and local governments.

The GEIS consists of three phases during the period summer 1998 through summer 2001: scoping the study; studying and analyzing the 12 scoped topics; and drafting and finalizing the GEIS. The EQB has established a 24-member Advisory Committee to provide advise to EQB during all phases of the GEIS. The scoping phase of the GEIS was completed in December of 1998.

This literature summary is the first step in the second phase aimed at study and analysis of the 12 key topics. This summary is intended to inform the Environmental Quality Board (EQB) members, EQB staff, and the Advisory Committee on the "Feedlot GEIS" scoping questions and research needed for adequate completion of the GEIS. The EQB would like to acknowledge the time and effort of the Advisory Committee members who provided invaluable input in the development of this "tool" for use throughout the GEIS process.

The literature summary is formatted to address the 12 topics of concern and 56 study questions outlined in the Feedlot GEIS Scoping Document (www.mnplan.state.mn.us). Any conclusions or inferences contained in this report are those of the authors and do not necessarily reflect the positions of the EQB or the Feedlot GEIS Advisory Committee.

The EQB would like to make this literature summary available to others interested in the effects of animal agriculture. Copies of this literature summary will be available for use in the Minnesota Planning/EQB Library, 300 Centennial Building, 658 Cedar Street, St. Paul. The Library will also house copies of the key literature review articles and the searchable database compiled as part of this literature review. A limited number of copies of this literature summary will be printed for distribution at cost.

For further information on the GEIS or this literature summary please contact the EQB at 651-296-9535.

Sincerely,

Gene Hugoson, Commissioner, Minnesota Department of Agriculture and
Chair, Minnesota Environmental Quality Board

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GEIS Update

FEEDLOT LITERATURE SUMMARY COMPLETE

During the period April through August 1999, nearly 100 University of Minnesota researchers, with partners from other universities and the private sector, pored through existing research in search of information on the 12 major topics in the Feedlot GEIS. The work is now complete as a 1,500 page analysis of their findings. Interdisciplinary research compiled the final document and all reports were reviewed by the EQB, a GEIS Advisory Committee and a group of external reviewers convened by the U of M for this project.

As a result of their efforts, the EQB will soon have a reference tool to use throughout the feedlot study.

> "The summary is an excellent starting point for the next level of EQB decision making. The summary points out the differences of opinion and the gaps in the research. The advisory committee and EQB will use this information as they decide on the additional research needed to complete the GEIS," **said EQB Chair, Gene Hugoson.**

Literature Summary Available
Because environmental agencies in other states and several libraries are showing strong interest in the research summary, the EQB will make a limited number of copies available for sale at the Minnesota Book Store 651/297-3000 (metro) and 800/657-3757 (nationwide) (M-F 8am-5pm).

The report will also be available in October at the MNPlanning/EQB Library, the Legislative Reference Library and regional libraries in St. Cloud, Willmar, Fergus Falls, Marshall, Mankato and Rochester. In early November, the EQB will post the report on the Minnesota Planning website at: www.mnplan.state.mn.us.

The literature summary work was completed under a tight timeline by nearly 100 researchers affiliated with the U of M. The GEIS Advisory Committee spent hundreds of hours reviewing drafts and advising the researchers on their work.

Next steps
The EQB will develop a study workplan in cooperation with the Advisory Committee and other state agencies in December 1999. When it is complete the workplan will identify the research needed to complete the feedlot GEIS. Contract researchers will conduct the analysis in the year 2000.

Feedlot Inventory Pilots
EQB is working with Minnesota Planning's Land Management Information Center (LMIC) and other groups to gather information on feedlot location and species, size of herd and number of operations in the state. Existing county level feedlot inventories augmented with statewide databases are the starting points for this count.

Pilot inventory projects now underway will allow the EQB to determine how to best gather similar information throughout the state.

The literature summary explores the research on 12 areas affected by the livestock industry. The topic areas are: social/community; land use; role of government; industry structure and competitiveness; profitability and economic viability; external benefits and costs; water; air quality and odor; soils; manure and crop nutrients; human health; and, animal health.

New AC Member
A 24 member Advisory Committee, appointed by the EQB, is charged with ensuring that the public, including interest groups and stakeholders, is involved in shaping the feedlot study and its findings.

The EQB welcomed **Pat Bloomgren**, Director of the Division of Environmental Health, Minnesota Department of Health, to the Advisory Committee in August. Pat brings years of experience working on tough environmental and public health issues for the state.

Farewell to Susan Schmidt
Michael Sullivan, EQB Director, notified the EQB at its September meeting that **Susan Schmidt** would be leaving the GEIS project October 15, 1999 to take on a new role as State Director of the Minnesota Office of the Trust for Public Land.

Sullivan said, "**Gregg Downing**, who remains as Co-Director of the GEIS Project, will provide staffing continuity while a replacement for Susan is sought." EQB hopes to have the new team in place by early November.

Background
Animal agriculture, a major component in Minnesota's economy has gone through dramatic changes. A decade-long consolidation of smaller farms into larger ones, a continuing shift to larger feedlots, and public concern over feedlot impact has generated much attention and controversy throughout our state.

As a result, the 1998 Legislature directed the EQB to conduct a statewide study of animal agriculture and feedlots to assess their present and projected impact on Minnesota. The study, a Generic Environmental Impact Statement (GEIS), is examining the effects of animal agriculture and feedlots on Minnesota's economy, health, environment and quality of life. The objective of the study is to provide balanced information on animal agriculture and recommendations on future options for animal agriculture in the state.

The comprehensive study is believed to be the first in the U.S. to explore the statewide impact of the entire livestock industry. When completed, the study will offer Minnesotans and their policymakers scientific data on the livestock industry and recommendations on future options for the industry.

The Environmental Quality Board, staffed by Minnesota Planning, draws together five citizens and the heads of 10 state agencies that play a vital role in Minnesota's environment and development. The board develops policy, creates long-range plans and reviews proposed projects that would significantly influence Minnesota's environment.

October 1999

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Topics

This *Summary of the Literature* has been prepared for the Environmental Quality Board by the University of Minnesota and its partners to inform GEIS decisionmaking. Any conclusions and inferences contained in the report are those of the authors and do not necessarily reflect the positions or policies of the EQB or the Advisory Committee convened to advise the EQB on the GEIS.

A *Social / Community*

B *Land Use*

C *Role of Government*

D+E *Industry Structure & Competitiveness*
Profitability and Economic Viability

F *External Costs and Benefits*

G *Water*

Social / Community

A

Generic Environmental Impact Statement on Animal Agriculture:
A Summary of the Literature Related to Social/Community (A)

Prepared for the Minnesota Environmental Quality Board

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EXECUTIVE SUMMARY: LITERATURE REVIEW ON SOCIAL/COMMUNITY IMPACTS

The structure of animal agriculture is changing. It includes consolidation at each stage of the value chain, from genetics through all stages of animal raising, animal slaughtering, disassembling of animals, and marketing. At the same time, vertical integration is occurring in the food chain so that increased ownership and control often accompany increased scale at each stage. Contracting is one form of vertical integration. Contracts reduce producer risk and reduce the degrees of freedom in animal management once the decision to contract has been made.

The impact of this consolidation has only been partially analyzed in peer reviewed studies in the fields of sociology, anthropology, geography and other social sciences. The largest body of literature is studies of meatpacking towns. There are also some comparative county-level studies looking at changing sizes of animal production units. Other than that, there are few studies that can answer the key questions regarding the impact of the changing structure of animal agriculture on the quality of life of Minnesotans in both rural and urban areas.

Studies to date suggest that the racial and ethnic composition in communities is changed with large animal units that require increased labor input. This is often accompanied by decreased residential stability. Associations of community members often form in opposition to large animal units, particularly when outsiders own them.

Some research suggests a distribution of power and authority shifts in rural communities where meatpacking plants enter, but no systematic studies have been done with other forms of animal production. Case studies show that leadership emerges from the movements in opposition to outside corporate animal agriculture entering rural communities. Neighborhood identity and neighborliness have increased in cases of successful opposition, documented by a case study in Michigan, but there is little systematic work in this area, particularly regarding vertical integration of farms already in the community.

Meatpacking town studies suggest that the demand for housing increases when new residents come in to perform jobs related to raising and slaughtering animals. The meatpacking town studies also show an increase in demands for public services, such as public safety and health; however, there is not systematic data on other forms of animal agriculture and its impact on public services.

There is little data on natural resource and land use, although case studies identify land use as a major source of conflict, as well as concerns about water quality and air quality.

There is nothing in the literature showing how the structure of animal agriculture relates to historical and cultural resources, except for case studies that document the importance of animal agriculture as part of local identity in some areas. Studies of community inequality (none relate that inequality to the structure of animal agriculture) show that

high inequality decreases the ability of the community to respond to difficulty. There is little analysis of community inequality, as affected by integrated animal agriculture, except in meatpacking towns.

The ability to work together to find solutions to problems has not been systematically studied, nor has trust between communities members.

Quality of life, separate from standard of living, in relation to different structures of animal agriculture has not been systematically measured.

Impacts of changing structure of animal agriculture on households and individuals, including farmers, has been little studied. There is some evidence that large confinement operations increase the perception of local residents of risk to their health.

Systematic studies of friendships and family relations, attitudes about social well-being, and enjoyment of property have also not been systematically addressed, although these factors lend themselves to comparative research. The meatpacking town studies suggest that attitudes toward cultural diversity are initially negative but can become more positive over time.

Individual quality of life of farmers or rural residents in relation to structure of animal agriculture has not been addressed, except in a series of studies looking at alternative production systems, particularly rotational grazing. These studies suggest that changing to these types of systems increase quality of life. There are no studies which examine the implications for quality of life from contract growing, which could include reduced stress and less sense of control.

The structure of animal agriculture studies shows some disequilibrium with what consumers demand and what they are willing to pay for. That includes animal well being while being raised and slaughtered. Ecosystem health, food safety, and food quality all require knowledge of the food supply. This requires preservation of the identity of the animal, including how it is treated, from conception to plate. It is not clear that the current structure of animal agriculture, with its concentration and vertical integration and scale, allow this to happen, although there are alternative systems in place that can take advantage of the consumer demand for these qualities in meat.

Another literature looks at citizen action, such as what citizens ask of government. Compared to other countries, the U.S. has much less regulation of animal care, even though consumers indicate a willingness to pay more for animals that have been treated humanely. Citizen action groups can impact regulation and subsidies for environmental enhancement related to animal agriculture. In particular, citizen action groups can force the internalization of externalities into the price of food produced through concentration and vertical integration. Citizens in action also impact government inspection and regulation.

There are many mechanisms now in place to resolve problems. Research suggests that these work better when they are carried out among neighbors who share a way of viewing the world. However, most of these mechanisms are based on anecdote and theory. There

has been no research to determine the effectiveness of different mechanisms under different circumstances.

The lack of research on these important questions suggests the need for systematic study in Minnesota. An approach to carrying out that key research is proposed. Simple description will not be sufficient.

INTRODUCTION

The major livestock sectors in U.S agriculture have undergone rapid transformation in the past several decades. Often referred to as restructuring, this process is characterized by rapid declines in number of farms, increased scale of production, growing concentration of market power among relatively few actors, and an increased vertical or contractual integration (Buttel and Jackson-Smith 1997). The production of different kinds of livestock – beef, dairy, broilers, hogs and turkey – has developed along parallel lines towards concentration and mass production. Changes in the location of animal agriculture have accompanied structural changes in animal agriculture.

Increasing, scholars refer to this as moving from supply chains to value chains (Cook 1997; Hughes 1998). Consolidation (the merging or close coordination of firms producing like goods) is increasing related to more highly coordinated value chains. But coordinated value chains do not necessarily depend upon consolidation or on increased scale of production.

SUPPLY CHAIN	VALUE CHAIN
PRODUCER ORIENTED	CONSUMER ORIENTED
SUPPLY DRIVEN	DEMAND DRIVEN
FOCUS ON QUANTITY	FOCUS ON QUALITY
FOCUS ON COST	FOCUS ON VALUE
SOURCE IS ANONYMOUS	IDENTITY IS PRESERVED
LARGE VOLUME MANAGEMENT	SMALL VOLUME MANAGEMENT
MANY INDEPENDENT DECISIONS	FEW CASCADING DECISIONS
OPEN	CLOSED

Rapid Declines in Number of Farms

The number of dairy farms in the U.S. declined by about 4.4 percent per year from 1982 to 1992 (U.S. Department of Commerce 1994a). Between 1992 and 1997 the number of farms with dairy cattle declined 25 percent (USDA Census of Agriculture). In Minnesota, the number of farms with dairy cattle declined 28 percent between 1992 and 1997. Restructuring of existing operations tend to require significant investments in increased

dairy cow numbers, increased or expanded livestock housing facilities, and modern highly automated parlor milking facilities (Jackson-Smith et al. 1996). In other areas of the country, corporate and cooperative dairies have been established, responding in part to the exodus of some of the dairy industry from California.

The large dairies are primarily in the West, Texas, Florida and upstate New York. Only a few have located in the traditional dairy farming areas of Wisconsin and Minnesota (Hart and Mayda 1998), although a few entrepreneurs have started to develop large-scale industrialized drylot dairy farms in the upper Midwest. In Minnesota, the average herd size increased from 45.7 to 56.4 cows between 1992 and 1997. In 1992, only one dairy farm had over 500 cows in Minnesota. Five years later, 29 Minnesota dairy farms had over 500 cows.

There is no research on social and community impacts of industrialized dairy operations in Wisconsin and Minnesota.

Beef production was centered in the Corn Belt from the late 1800s through the mid 1970s, with most feedlots holding no more than a few hundred head and relying mostly on crops grown on the farm. Since World War II, the small farm feedlots have been superseded by very large feedlots in the West with capacities in the tens of thousands (Hart and Mayda 1998). One exception to this structural and geographic transformation in the beef industry is Wisconsin, where the scale and size of livestock production remain relatively small (Buttel and Jackson-Smith 1997). The bulk of fed cattle produced nationally are done by a very small handful of very large cattle feedlots (Welsh 1996). Minnesota is not among the ten states with the highest number of cattle in feedlots between 1992 and 1998. However, Minnesota continues to have substantial numbers of cow calf and stocker feeder operations.

As in the dairy sector, relatively little empirical research has linked macro-level structural changes in the animal agriculture industry with grassroots social and community impacts. The research conducted to date suggests linking different levels of analyses can be fraught with methodological and analytical challenges that could limit the veracity of findings.

Increased Scale of Production

Many studies analyze changes in the geographical location of animal production facilities and changes in size of production units (Zering 1998; Ginder 1998; Hart and Mayda 1998; Buttel and Jackson-Smith 1997; Ikerd 1998; Thu and Durrenberger 1998). For example, North Carolina became a new center of the hog industry in the 1990s (accounting for 37 percent of the increase in national inventory on farms with at least 200 hogs). Missouri and Minnesota have experienced rapid increases in their hog inventories in the 1990s as well, with Missouri adding up to 700,000 hogs and Minnesota 150,000 hogs (Zering 1998). In Iowa, still the state with the largest hog production, and in Minnesota, the industry traditionally relied on family farm production, with an average of 500 to 999 head. These operations were part of a diversified farming strategy that included row crops. More recently the hog industry in Iowa has seen rapid expansion of

large confined animal feeding operations (CAFOs) and state- of -the -art production that facilitates the mass-production of pigs (Kliebenstein and Hurley 1999). However, in the Netherlands, state of the art technology production systems and constantly improving genetics are used on small farms, with only a few hundred animal units (Kemp, 1999). Thus in Iowa there are more hogs in fewer counties in 1999 than in 1992. In Minnesota, the number of farms selling hogs decreased from 13,749 to 7,717 between 1992 and 1997 (U.S. Census of Agriculture, 1997). However, the number of hogs sold increased from 9,141,699 to 12,943,053 during the same period. Number of hogs sold and number of farms selling hogs decreased in 50 Minnesota counties, while the number of hogs sold increased although the number of farms selling hogs decreased in 35 Minnesota counties.

These transformations in the hog industry reflect a process of restructuring that has had important implications for the independent hog producer and the communities in which such farms are embedded. Prior to the 1980s, hog production in the U.S. had typically occurred on diversified family farms in which the farmer had virtual autonomy in critical production and marketing decisions (Hart and Mayda 1998).

Hog producers had relatively open access to production technology, genetics and slaughter facilities through the 1980s (Ginder 1998). The emergence of systems based on uniform genetics, phased feeding, all in/all out occupancy and integration or forward contracting of the animal on the one hand limits access and on the other hand cuts transaction costs (Ginder 1998; Padgitt and Lasley 1995).

Developed outside the Midwest, these coordinated genetics to wholesale systems are moving into the core hog production areas of the Corn Belt (Ginder 1998; Kliebenstein and Hurley 1999). The shift in size and scale of hog operations is accompanied by a geographical shift in location of hog operations across the U.S. The social impacts of geographical shifts in the animal agriculture industry for communities that are losing as well as those that are gaining hog operations are only beginning to be systematically researched.

Growing Concentration of Market Power among Relatively Few Actors

An alternative management system for beef and dairy is rapidly evolving in Wisconsin and Minnesota, traditional dairy regions in the Midwest (Buttel and Jackson-Smith 1997). Some scholars suggest it holds interesting implications for farm household and community viability (Hassanein and Kloppenburg 1995; Meares 1997). This alternative system of management relies on the intensive use of pastures as the main source of feed. Referred to as management intensive rotational grazing, Voisin management, or management intensive grazing, the system has been touted as extremely competitive and a potentially more sustainable alternative to the conventional capital intensive dairy operation. Its competitiveness hinges on major reductions in input costs, lower risk exposure to price fluctuations, reduced labor requirements, improved herd health, better quality of family life, and improved environmental outcomes (Jackson-Smith et al. 1996). The number of farms with beef cows increased slightly in Minnesota between 1992 and 1997 – from 15,101 to 15,745, while number of beef cows on farms increased from 381,869 to 409,184. Total number of farms with in Minnesota with steers, steer calves,

bull calves, and bulls declined nine percent from 27,888 in 1992 to 25,524 in 1997. Number of these animals on those farms declined four percent (USDA, Census of Agriculture, 1997).

Concentration in the poultry sector began in the late 1950s (Soule, Tabor and Kirkwood 1960). In more recent years the production of poultry is concentrated on the eastern half of the United States. Nearly 83 percent of U.S. poultry farms are now found in the Northeast, Appalachian, Southeast, Delta and Corn Belt regions (Perry et al. 1999). Historical developments in technology and increased competitive pressure as far back as the 1960s resulted in increased vertical integration of the broiler industry (Soule, Tabor and Kirkwood 1960). With a few exceptions (Heffernan 1995), there is a dearth of analysis of the social and community impacts of vertical integration in the poultry industry, particularly broilers. In Minnesota between 1992 and 1997, number of farms with broilers decreased slightly from 679 to 621, while number of chickens sold decreased from 37 million to 28.5 million. In 1995, 47 million turkeys were raised on 359 farms in Minnesota. In 1992, 44,164,778 turkeys were raised on 390 farms in Minnesota. Integration in turkeys is significantly different enough from that of broilers so that separate analysis would be helpful.

Increased Vertical or Contractual Integration

Vertical integration refers to control by a single management of two or more stages of production in an industry. The process is achieved in predominantly two ways. Control of management of multiple stages of the production is achieved by mergers or by the expansion of given firms resulting in ownership integration. In other cases, vertical integration is achieved by systems of contracts that are used to coordinate the activities of nominally independent enterprises, a process described as contract integration (Soule 1960). According to Vurkina and Foster (1998), contract growers now produce close to 90 percent of U.S. broilers. As Welsh and Hubbell (1999) have observed, many analysts are now predicting that other livestock industries like pork and dairy may likely mirror this pattern of vertical integration and contracts. One form of vertical integration is corporate ownership of land facilities and animals, which hires labor to perform all the tasks, from breeding to wholesale. Contracts are another form of vertical integration. Contracts help reduce risk and stabilize income for the grower. For the processor they provide a timely supply of known quantity and quality.

The bulk of the existing literature on contract production emphasizes whether the contracts are economically viable for the producers. The conventional view of these arrangements is enthusiastic. Contract production and vertical integration are thought to be more efficient, better for the processor, better for the grower and better for the consumer (Banker and Perry 1999; Hoppe 1996; Martinez 1999: Perry et al. 1997; Harrison 1998).

Non-farmers are also affected by vertical integration. Lenders, for example, often encourage growers to investigate production contacts (Walster 1998; Brunoeler 1998). Livestock production for poultry and hogs contracts are different from more familiar forward contracting of a commodity in a supply chain. A forward contract is generally a

sales agreement between the farmer and a buyer that involves an agreed upon price and other terms to be carried out as to some future date. Generally, in hog and broiler contracts discussed here, the grower provides the land and buildings, equips the buildings to the processor's specifications, and provides all labor for the production. Growers never own the birds or animals or the feed. The processor provides the animals, feed and medication.

In most hog and broiler production contracts, one party—referred to here as the processor—owns the animals and delivers them to be raised by a second party. The second party—referred to here as the grower—provides the labor and location for raising the animals. Livestock production contracts of this type are almost universal in the broiler industry and of increasing importance in hog production. These types of contacts are rarely found in the beef industry for either cow/calf or stocker/feeder operations or in lamb production.

Extent of Contract Production

Production contracts already dominate the broiler industry and likely will continue to do so. After being raised primarily by independent producers for decades, hogs are increasingly raised through production contracts.

At present, in the country as a whole, about one-third of the value of hog production occurs under a production contract. More than 70 percent of the value of poultry production is produced under a production contract, and around 10 percent of the value of cattle production is produced under contract. Contract hog production has increased every year over the last decade. The extent of contract production is well documented. USDA, for example, issues regular reports detailing this data. USDA provides no analysis of the social impact of these contracts in this information.

Nature of the Production Contract Relationship

Only in the last five years has a literature describing the nature of production contracts begun to appear (Hamilton 1995; Kelly 1995). Because poultry production became integrated several years before hog production, there is more written about poultry (Fulcher 1992). An older literature addresses some contract interpretation issues that are raised with production contracts (87 ALR2d 732). The extents to which the contracts exert control over the day-to-day operations of the farmer are almost never discussed in the literature. The following provisions found in hog and poultry contracts are typical, not aberrant.

Contracts Contingent on Single Use Facilities: Typically processors will not contract with a producer of poultry or hogs unless the producer's facilities meet the exact specifications proposed by the processor. This usually requires the farmer to build a new single-purpose production facility. Such facilities typically cost more than $500,000.

Growers Are Obligated to Follow Processor Instructions regarding Production Techniques: Typically all management practices advocated by the integrator must be followed strictly. Because the language of the contracts is so strong and so out of character with most farming arrangements, they are quoted here directly.

> Grower will adhere to the feeding and health programs and management recommendations provided by [Processor], cooperate fully with . . . [Processor] to make records available, and comply with all laws and regulations applicable to the feeding and care of [Processor's animals].
>
> The [Grower] must feed and can care for birds according to [Processor's] Management Guide and . . . as directed by [Processor's] representative. The Grower must have all buildings, equipment, facilities for raising of birds under this agreement in conditions satisfactory to" the [Processor].
>
> Grower must care for the animals in accordance with [Processor's] . . . management program, which will be modified from time to time by [Processor], either in written form or verbally through . . . personnel.
>
> Animals must be raised in strict accordance with the [Processor's] feeding program and management program, as communicated from time to time by [Processor].

Processor May Inspect the Premises, Take over the Operation without Grower's Consent

The Processor

> Shall have the right of access at all times to the premises in which the [Animals] are grown for the purposes of inspecting the [Animals]. In the event that the grower does not comply with manure management . . . or waste disposal,
>
> Grower hereby grants [Processor] full and complete access to the Facilities to carry out Grower's duties at the expense of the Grower. In such event, Grower agrees to indemnify and hold harmless [Processor] from any claim, losses or damage which results from Grower's failure to comply with this provision, including without limitation any claim, loss, or damage which results from [Processor's] actions in performing Grower duties.

Processor may

> Enter upon the premises of the [Grower] to inspect the flock or facilities. If the [Processor] is not satisfactorily performing obligations as outlined in [Processor's] established procedures (in addition to contract), [Processor] may remove the flock, or maintain there, and [Grower] assumes all costs.

If the processor feels that the grower is in default, the producer may

> At its sole discretion enter the premises, remove the [Animals], or take over the operation of the facility.

If the grower does not care for the operation

> As directed by [Processor] then [Processor] shall have the right to care for, treat and maintain said animal and move the flock or leave it in the Grower's houses in [Processor's] sole discretion.

If Processor

> Determines that grower is not following the [Processor] Management Guide or is otherwise improperly or negligently feeding, watering, or otherwise caring for said [Animals] . . . [Processor] may at its option immediately terminate . . . the agreement.

The processor has the right to

> Come upon the premise where [Animals] are situated, without court order or other writ, take possession . . . take whatever steps are necessary to raise [Animals] to market age on grower's premises, even to the exclusion of the grower. Grower pays costs in furnishing care and attention . . . no fee to grower.

The ability of the processor to enter the property and take over the property at the processor's "sole discretion" is common—not unusual.

Contract Livestock Production

Production contracts routinely assert that the grower works as an independent contractor, not an employee. The distinction has a number of important implications, particularly in federal income taxation, unemployment insurance, premises and employee liability, and others. Because the contracts remove so much autonomy from the producer, some writing raises the question of whether production contracts create an employee-employer relationship (Becker and Haas 1996).

Fairness of Contracts

A growing literature is critical of production contracts, primarily for their one-sidedness and for the fact that contracting speeds the vertical integration of the livestock industry (Hegar 1998; Prim 1998). One result from these concerns is a growing literature seeking to advise farmers how to enter into production contracts wisely (Kunkel and Lairson 1998; Iowa Department of Justice 1996).

Other writers are more critical of production contracts. This writing emphasizes what is thought to be extremely unfair terms in the contracts, as well as problems of processors breaching contracts in an aggressive way. Several fraud cases have resulted (Roth 1995; USDA *Federal Register* 1997). Beyond what is known about the social effects of

dispossessing producers, this literature does not address social consequences of these difficulties.

Environmental Concerns

Large livestock production facilities increasingly face scrutiny for environmental problems, particularly odors and other nuisances. These discussions tend to skip over issues of control, and usually left unnoticed is that production contracts make the grower legally responsible for all environmental damage. Though processors own the animals, growers are responsible for disposing of all dead animals and are responsible for all environmental consequences of the operation (Voogt 1996; Carpenter 1999).

Regulations of Contracts

Historically, legislatures have exerted significant power to limit certain contracting practices. In general this is to ensure that unconscionable contracts are not enforced. A small but helpful literature describes some of these efforts (Hamilton and Andrews 1993).

Animal producers give up a certain amount of independence, management authority, and flexibility for a certain amount of financial security. Systematic research has not address the social implications of this trade off.

1. CRITIQUE OF SCOPING DOCUMENT STUDY QUESTIONS

QUESTION #1

Question 1 suggests an array of possible social impacts resulting from changes in the structure of agriculture. While this is a good question, it has not been a topic of research in the past. We found very little work that used systematic comparative analysis, although we were able to glean impacts from case studies. Case studies are most useful in understanding the local *process* through which change occurs. Generally retrospective, they provide rich detail and insights missing in surveys and secondary data analysis. However, case study *results,* in terms of which causes yield which effects, are limited, because it is impossible to eliminate rival causal factors, as can be approximated with laboratory experiments or statistical analysis.

QUESTION #2

We have assumed that question 2 should read "What is the relation between changes in the ownership, control and legal structure in the animal agriculture industry and how these changes affect the way that stakeholders are identified, the way the affected public is responded to, or the benefits that accrue to the local community?

This question suggests a good set of variables to look at regarding changes in ownership, control and legal structures in animal agriculture industry. However, the term "how stakeholders are identified" is not clear because there is no actor. This is a passive statement, as is "the way the affected public is responded to." Responded to by whom? The passive voice did not lead us very far into addressing this question.

We would also suggest that benefits accruing to the local community are really part of the dependent variables addressed in question 1. It might be more useful to integrate question 2 into question 1, focusing on research that has looked at changes in ownership, control and legal structures in the animal industry and research that has looked at those changes in the variables laid out in the question 1.

QUESTION #3

One point of clarification suggested for Question 3 deals with the definition of consumer vs. citizen. There is a body of literature on consumer attitudes towards meat where "consumer" and "citizen" are the same individuals, but in relationships to different aspects of society. A consumer is an individual interacting with the market, while a citizen is an individual interacting with government. Consumers and citizens often come together to apply pressure to the market and to government, which gives them more power than individual decisions in shopping or in balloting. It might be better to phrase this in terms of consumers and citizen action groups. Consumers may be able to affect animal agriculture production systems through market choices and pressure on retailers and processors, and citizen action groups may be able to affect animal agriculture production systems through influencing government policy.

QUESTION #4

Question 4 raises important issues but should be more clearly articulated. Do "perceived problems" refer to conflicts resulting from changes in animal production systems or conflicts resulting from changes in the neighborhood population? More applied studies based on actual experiences of animal agriculture-based conflict resolution are needed, as there is little literature that addresses these problems. It might be better to phrase the question, "What are the problems or conflicts that arise between producers and their neighbors related to animal agriculture? What mechanisms are effective in resolving those conflicts?"

CRITICAL REVIEW OF INFORMATION SOURCES

THE STRUCTURE OF ANIMAL AGRICULTURE IS CHANGING. IT INCLUDES CONSOLIDATION AT EACH STAGE OF THE VALUE CHAIN, FROM

SCOPING DOCUMENT QUESTION 1: WHAT IS THE RELATION BETWEEN DIFFERENT TYPES OF ANIMAL AGRICULTURE PRODUCTION SYSTEMS AND THE FOLLOWING SOCIAL ELEMENTS:

1a. Demographics (racial and ethnic distribution, residential stability, residency)

The few studies that have looked at animal agriculture within the context of demographic change suggest a linkage between low income, predominantly minority communities and the proximal location of CAFOs (confined animal feeding operations) (Wing et al. 1996; Epstein 1995; Collin et al. 1995). Researchers at the University of North Carolina conducted a case study where a large hog production facility was sited in a poorer area in eastern North Carolina (Wing et al. 1996). Studies of meatpacking locations suggest that they are associated with an increase in foreign-born minority populations (Gouveia and Stull 1995; Fink 1998; Stull, Broadway and Griffith 1994).

Stephen Bloom (1996, p. 36) notes that:

"The rural Heartland is up for auction, and the bidders are thousands of new pioneers arriving each month. They are taking the places of the old who are dying and the young who are leaving. In not just a few windblown towns, the newly arrived are immigrants, driven from their homes in Asia, Latin America, Africa, Eastern Europe...The number of legal immigrants who arrived in America between 1990 and 1993- 10.6 million- is nearly double the number of those who arrived the preceding 13 years...Increasingly large numbers of immigrants are moving east and west, converging upon the Heartland in waves of secondary migration. While the overall growth of rural small towns nationally has taken a nose dive since 1980, the number of Asian immigrants who have moved to rural America has jumped 42 per cent to more than 600,000 and the number of Hispanics has increased 23 per cent to more than three million. In Minnesota, the Hispanic population jumped 68 per cent in the 1980s; in Kansas it grew 48 per cent; in Iowa, it rose 28 per cent."

Gouveia and Stull (1995) conducted a comparative case study of two beef packing house towns in the rural Midwest—Garden City, Kansas, and Lexington, Nebraska. The scholars surmised that such communities offer a "natural experiment for social analysis of a rural industrialization process in the context of its expected and real benefits and costs to families and community." Population and its diversity increased, while the communities struggled with the issues of the needs of population increase and culture and language differences.

However, what happens as the meat packing industry moves west can be very different than the impact of established meat-packing firms in Minnesota.

Empirical evidence relating to residential instability and changes in residency patterns in communities proximal to CAFOs and/or larger than family-sized animal agriculture operations with 1,000+ operations is non-existent in refereed literature. Both net (the difference between the number of people moving in and the number of people moving out) county migration and gross (the number moving in and the number moving out) county migration are important indicators of community impact. Gross migration (high population turn over) is an important indicator of the strength of local social systems and the degree of social control they are able to enforce.

1b. Community and Institutional Factors (size and structure of local government, linkages between levels of government, voluntary and other associations, employment and income characteristics, and opportunities for new wealth).

We discovered no studies relating size and structure of local government to the structure of animal agriculture, although some research in process suggests that demands on services provided by local government does increase. Likewise, there were no systematic studies of the linkages between levels of government that resulted from different types of animal systems.

DeLind, in her research in Michigan, found that local voluntary associations sprang up in opposition to the restructuring of hog production. Deborah Fink, in a case study in Perry, Iowa, showed the emergence of voluntary associations in opposition to the meat packing plant. A local environmental group, Citizens against River Pollution, organized against IBP for polluting the Cedar River in southeastern Iowa, an example of grassroots association responses to community impacts of restructuring in the meat processing industry. Religious and community leaders' also organized in response to community breakdown associated with IBPs high turnover rate and low wages, and the consequent heavy tolls on social services

Employment and income characteristics are better addressed in the section on externalities. However, issues of equity and the structure of livestock production have strong social and community implications.

Different types of animal production systems characteristically reflect different socio-economic, employment and income implications and impacts at the level of the farm and community (Durrenberger and Thu 1996; Jackson-Smith et al. 1996; Ikerd 1998; Welsh 1996; Flora and Flora 1987). The research generally relates the size of livestock operation to indicators of community well-being.

The interaction between changes in the livestock sector and community, as examined in other regions of the country, can be instructive for the Minnesota context and are briefly summarized. A study in the Great Plains and west of the Missouri River examined how four different kinds of agricultural systems affect the welfare of agricultural communities (Flora and Flora 1987). Large-scale livestock counties were the least likely of the four farming systems studied to generate economically healthy communities. They had fewer retail sales per capita, fewer wholesale establishments, lower median family income in both 1969 and 1979, and a larger proportion of the population in poverty. The analysis also indicated that large-scale livestock counties had the highest number of families below the poverty line in both 1969 and 1979. But the percent in poverty declined more rapidly than in other agricultural counties, suggesting that either the poor had left the county or that new income generation mechanisms had been

introduced. These findings are dependent in part on the expansionary agricultural setting of the 1970s. Studies conducted in the late 1990s might reveal quite different relationships between shifts in farm size and shifts in the well-being of county residents. The Floras' findings are consistent with more recent studies that have looked at the effects of structural changes in agriculture on county vitality and viability nationally (Lobao 1990) and in Iowa (Lasley, Hoiberg and Bultena 1992).

Posing the question, "Is it better to have fewer large farms or more small farms," researchers at the University of Iowa examined the dynamic changes and debates occurring in Iowa's multi-billion dollar hog industry and its social impacts on rural communities (Durrenberger and Thu 1996). The main impetus for the study arose out of a concern that in the absence of scientifically-based research on structural change and community impacts, local policy makers run the risk of making decisions based on unquestioned cultural assumptions about the efficacy of reorganizing swine production. There is a need, they stated, for empirical studies on the livestock/community nexus to inform policies and implement strategies that can enhance rather then diminish the social and economic wellbeing of producers and communities.

A study of the livestock industry by researchers in Wisconsin provides evidence of the relationship between technology, markets, concentration of livestock on a few relatively large farms, and community wellbeing (Buttel and Jackson-Smith 1997). Their study attempted to throw light on recent debates in Wisconsin relating to whether "industrialized" or large-scale animal agriculture will (or should) play a more prominent role in the Wisconsin livestock sector. Their research paper summarized farmers' views on a wide range of issues relating to the expansion and industrialization of animal agriculture.

The research sought to determine how the rank and file of farmers felt about the proposed expansion of the livestock industry. To systematically explore that issue, the researchers conducted a mail survey of 1,100 randomly selected Wisconsin farmers. Results of the analysis showed that farmers tend to be very lukewarm about livestock expansion. Farmer respondents were least supportive of hog and poultry expansion. Only 17 percent of the respondents perceived expansion in the livestock industry as a good initiative, while 45 percent perceived it to be negative. Wisconsin farmers' views towards livestock expansion were not shaped primarily by concerns about the environment but instead by concerns about farm structure in their state. Farmers' responses indicated a strong support for family-scale operations as opposed to industrial, non-farm investor type of animal operations. The authors concluded that the bulk of the farmers who oppose livestock expansion do so because of a strong concern that it would erode the status of family farming in the state. Farmers in the neighboring state of Minnesota, who have similar operations and backgrounds, are likely to share those concerns.

An emerging literature analyzes the livestock-processing sector, which in the last decades have taken root in predominantly rural communities (Grey 1995; Gouveia and Stull 1995; Stull, Broadway and Griffith 1994; Lamphere, Stepick and Grenier 1994). The studies document the changing quality of life conditions of meatpacking workers and the rural communities in which they are embedded. These studies focus on communities where meat processing has recently been established, rather than on the more established meat packing communities in Minnesota.

Deborah Fink (1998), in an in-depth, participant observation and ethnographic study of an IBP livestock processing plant located in Perry, Iowa, examined the social and economic contradictions inherent in the restructuring of the meat processing industry in rural Iowa. The study drew on interviews with 125 plant workers, 63 interviews from the Iowa Labor History Oral Project and 12 interviews from the United Packinghouse Workers of America Oral History. Other primary sources of data included union records, company reports and brochures, manuscripts, census data and government reports.

Fink drew out critical gender, ethnic and racial inequities in the division of labor in meat packing plants. Who gets to do what, her analysis illustrated, was more often determined by the color of one's skin or the geographical region of origin, complexly intertwined with whether one happened to be a man or a woman.

Community studies of meatpacking plant impacts focus on changes in the size and characteristics of the population, and the insertion of new sources of point pollution. These in turn impact public services and day-to-day interaction of community residents. Contract animal production is less likely to require much additional labor, although potential point pollution sources increase. Thus there are some parallels that can be usefully drawn from these studies, but primarily in terms of public concern about environmental quality.

1c. Political and Social Resources (distribution of power and authority, leadership, channels of complaint response and redress, changes in the way stakeholder groups are identified, and ownership patterns)

Distribution of Power and Authority, Leadership

No research was identified that specifically related a discussion of the distribution of power and authority and leadership to changes in the animal/livestock systems. These are important areas for further research, as analyses could help illuminate important elements of leadership structure associated with different kinds of animal agriculture systems and their social implications for community.

There are a number of classic as well as recent community studies that show how the ownership and control of industry in rural areas influences power relations and leadership. Pope (1942), in his classic study of Gastonia, North Carolina, shows the disempowerment of labor and the local community as the mills shifted from local to "foreign" (the Northeast region of the U.S.) ownership and management. Duncan (1999), in comparing the Mississippi Delta, Appalachia and New Hampshire, demonstrates the differential impacts of local vs. outside control in the New Hampshire Appalachia comparison. In the Delta, she found local agriculture ownership, which was very concentrated, was related to ineffective local institutions and non-existent local leadership. The farming systems in the Delta have very few animals.

Hart and Mayda (1997) discuss the emergence of a large hog-producing region in southwestern Kansas and the panhandles of Oklahoma and Texas. They contend that the key to the emergence of this region as a major source of hog production is a processing plant that was built near Guymon, Oklahoma, by the Seaboard Corporation. The corporation has the capacity to process

1,000 hogs per hour and has developed its own hog farms to ensure a steady supply. Opposition to the hog farms, primarily from communities and farmland preservationists, was analyzed and discussed. The researchers concluded that the controversy will continue and could be made more complex by the fact that the new hog-producing region is located in four separate political jurisdictions.

Channels of Complaint Response and Redress

Through a case study methodology, researchers at Sam Houston State University document the actions of anti-CAFO groups in the Texas Panhandle (Constance and Bonanno 1999). They show the difficulties associated with reconciliation of the goal of socioeconomic development in rural areas with that of the protection of the environment and of the enhancement of the quality of life of rural residents. An incident at the Palo Duro feedyard and the F/R cattle Lawsuit were examined.

The study focused primarily on episodes of resistance carried out by local residents and environmental groups. The residents were mainly motivated by concerns about human health and property values. The analysis documented the corporate responses to community resistance to CAFOs, which primarily constituted a reconstruction of the corporate image as environmentally sound.

A similar case study illuminated some of the qualitative long- and short-term effects of conflict generated by the siting of a swine confinement production facility in Parma, Michigan (DeLind 1995). In the mid-80s, Sand Livestock Systems Inc. constructed five hog confinement units in Parma. Controversy erupted soon after when the corporation's three open-air (42 million gallons capacity) manure lagoons began emitting a "horrific stench" that compromised the health and quality of life of the neighborhoods surrounding the facility. Local resistance culminated in the emergence of two grassroots organizations and a four-year litigation process. The case study showed that the long- and short-term consequences of this conflict were anger on the part of community residents who believed that their environment and their integrity had been violated, resentment towards public officials, polarization within the community, and a sense of alienation. Paradoxically, the conflict eventually emerged as a basis of community identity and social cohesion. The perceived assault to quality of life became a basis for increased interdependency among community residents, shared resources, and a sense of mutual responsibility. Grassroots responses to the changing structure of animal agriculture may hold important implications for resolving potential emergent conflicts, and therefore merit systematic analysis in order to unweave and understand its complex dynamics. Such consequences could become salient factors in the context of the changing livestock industry in Minnesota.

Changes in the Way Stakeholder Groups are Identified

No research or literature examining relationships between changes in animal agriculture and stakeholder identification was found. There is important literature on stakeholder analysis in the context of resource management, but the research has not been framed directly in relation to animal agriculture systems.

Ownership Patterns

Land ownership for all but totally integrated poultry and hog production remains in the hands of farm families and their heirs. What varies is the ownership of the animals (Welsh and Hubbell 1999). As contract production becomes a feature in the agricultural landscape, ownership and control of animals and their management is in the hands of non-agricultural firms that engage farm level workers including farmers to grow products. The implications of this pattern in local communities are only beginning to be researched.

1d. Individual and Family Changes

Perceptions of Personal Risk to Health and Safety

The section on human health will deal with studies of the impact of different forms of animal production on human health. As noted above, perceived threats to human health have motivated the formation and activism of local groups in opposition to CAFOs (DeLind 1995; Fink 1998)

Trust in Institutions, Friendships and Family Relations, Attitudes about Social Well-being, Job Satisfaction, Neighborhood Identity and Neighborliness, Attitudes towards Cultural Diversity

DeLind's study in Michigan demonstrates decreasing trust in institutions and break up of friendships in response to a CAFO locating in a community. The meatpacking studies indicated an initial increase in racism with the introduction of the plant. The first workers were mostly single men – who behaved at times like other groups of single men in college or military towns. There were then counter movements in the population to combat racism, which increased as more families settled in the community.

Enjoyment of Property

Using the Profile of Mood States (POMS), Schiffman and colleagues (1995) attempted to determine the effect of environmental odors emanating from CAFOs in North Carolina on the mood of nearby residents. The scores for six POMS factors and the total mood disturbance (TMD) score for 44 experimental subjects were compared to those of 44 control subjects who were matched according to gender, race, age and years of education. The results indicated a significant difference between control and experimental subjects for all six POMS factors and the TMD. Persons living near the CAFOs who experienced the odors reported significantly more tension, more depression, more anger, less vigor, more fatigue and more confusion than control subjects. Persons exposed to odors also had more total mood disturbance than control subjects as determined by their ratings on the POMS.

In a Dutch study designed along similar lines, researchers measured odor emission and dispersion and related these measurements to data from a survey of individuals in residential areas nearby (Miedema and Ham 1988). Three odor sources were examined: a rapeseed oil

extraction facility, an electric wire insulation factory, and a pig farm. Although the article focused primarily on the technical task of measuring odor, findings showed that increasing odor levels were highly correlated with increased annoyance on the part of residents and with behaviors or conditions such as having to shut windows, being prevented from sleeping, having to avoid deep breaths and headaches. This was as true for the individuals living near pig farms as for individuals living near the other facilities.

Implications of changes in livestock production for the enjoyment of property in surrounding rural communities are also broadly addressed, but they tend to proliferate in the non-academic literature.

1e. Community Resources

No studies were identified in the literature that linked housing, public services, natural resources and land use, and historical and cultural resources to the changing structure of animal agriculture. While they are not reviewed in this report, studies do exist that discuss these elements in the context of broader changes in agriculture. Studies of meatpacking towns (Stull, Broadway and Griffith 1994) related acute shortages in affordable housing for workers, who lived in mobile home parks often outside city limits. Unsatisfactory housing arrangements often increased worker geographic mobility. However, research in Nebraska shows foreign-born packing plant workers are generally more satisfied with local housing than long-term residents. New businesses were created in meatpacking towns, usually by the in-migrants, meeting the cultural needs of the new residents and increasing the diversity of goods and services available to the entire community.

The meatpacking town literature shows increased public investment in police and schools (Grey, 1995; Gouveia and Stull 1995; Stull, Broadway and Griffith 1994; Lamphere, Stepick and Grenier 1994). Grey also found that, because it takes six months for plant workers to receive health benefits, number of unpaid bills at the community hospital increased dramatically. That demand on public services put a severe financial strain on the county.

1f. Social Capital

Degree of mutual trust, reciprocity, and shared norms and identity are important elements of social capital. Social capital inheres in relationships between and among groups. The literature review shows that social capital has emerged as an internal resource in different instances of controversies and conflicts related to changes in animal agriculture, such as health, odor, housing and residential issues. Thus this thematic topic is discussed in different sections of the literature review where it has emerged as a factor in the resolution of a conflict or vice versa.

1g. Quality of Life

Quality of life factors similarly permeate the literature where large-scale factory operations are examined in the context of social community impacts and are interwoven in areas in the literature where it emerges as an element in the findings of a study. Quality of life is related to perceptions of 1) having alternatives in what one does on a daily or life cycle basis, and 2) being

respected by family and communities of interest and place. Quality of life is different than standard of living, which is discussed in other sections.

Studies of rotational grazing as an alternative way of structuring production indicate that farmers perceive an increased quality of life when they move to the alternative systems of production (Meares, 1997).

SCOPING DOCUMENT QUESTION 2: WHAT IS THE RELATION BETWEEN CHANGES IN THE OWNERSHIP, CONTROL AND LEGAL STRUCTURE IN THE ANIMAL AGRICULTURE INDUSTRY AND HOW THESE CHANGES AFFECT THE WAY STAKEHOLDERS ARE IDENTIFIED, THE WAY THE AFFECTED PUBLIC IS RESPONDED TO, OR THE BENEFITS THAT ACCRUE TO THE LOCAL COMMUNITY

Although one might infer certain social impacts from the precise change in legal status resulting from contract production, no significant literature addresses the issue directly. Poultry, hog and, perhaps someday, significant cattle production will be arranged using a system of contracts that change social relationships a great deal. Thus far little is known about the specifically social results of that transition.

The analysis that has been done looks at the income of farmers with production contracts and is discussed in the section on regional economics. Little systematic research has been done on animal producers who loose production contracts. Nor has the impact on local communities of different forms of contracting versus spot market sales been examined.

SCOPING DOCUMENT QUESTION 3: WHAT IS THE RELATION BETWEEN ANIMAL AGRICULTURE PRODUCTION SYSTEMS AND CONSUMER AND CITIZEN ATTITUDES WITH RESPECT TO

3A. QUALITY OF ANIMAL PRODUCTS AND FOOD SAFETY

For a long time food industry and government officials have trumpeted the superior quality of processed foods made in the U.S. (Hiebert 1991). But even as agroindustrialization proceeds apace in many parts of the country (notably including Minnesota), even industry insiders are starting to admit that changes in production systems have provoked a profound and ominous change in human relationships with the environment. In particular, we have engineered the possibility for a whole range of foodborne pathogens to make themselves better known to the public. Some of these microbial newsmakers are relatively new and present special challenges to public health officials and state legislatures trying to cope with outbreaks of debilitating or deadly disease encountered in such familiar parts of the American cultural landscape as the fast-food restaurant. Yet just as important, some of the more recent and especially troubling foodborne diseases have been caused by pathogens well known to us for a long time but, through changes in production and consumption patterns, now are able to find greater opportunity to make their presence felt (Fox 1997).

For example, one of the most difficult foodborne pathogens to control is *Listeria.* It is considered by at least one group of medical researchers to have a higher fatality rate than any other foodborne disease, including botulism (Bellin, Broome and Bibb 1991). Investigators working

for the American Meat Institute (1987, pp. 1-13) found *Listeria* in one-third of all cultures taken from floors and drains sampled in meat-processing plants, as well as in more than one-fifth of cultures taken from wash areas and other areas with which food comes into contact. Fox (1997, pp. 274-275) points out that *Listeria* can be transmitted from animals to other foods with ease. Fatal outbreaks of Listeriosis throughout the 1980s in Boston, Philadelphia, Los Angeles, and elsewhere involved coleslaw, milk, turkey hot dogs, soft cheese, salami, ice cream, pâté and mineral oil.

Issues of food safety in relation to the quality of animal products are thrown into stark relief when it is realized that Listeriosis is just one example of an expanding list of foodborne diseases with which we now have to contend. However, generalizations can be drawn about how changes in agriculture have created such a situation. On the production side, at least two dimensions are important to note.

1. The increased incidence of foodborne diseases has, in part, been facilitated by changes in techniques used to raise animals for slaughter.

The first instance of foodborne Listeriosis (in 1981) involved cabbage used for coleslaw, which was grown in a field fertilized with manure from *Listeria*-infected sheep. But while some may expect trouble to follow from the use of fecal matter to increase crop yield, it is likewise important to note that changes in processing and marketing have also provided *Listeria* new opportunities to reach the consumer. The 1983 fatal outbreak of Listeriosis involved milk that had been pasteurized, and a later incident involved turkey hot dogs that had been microwaved before being eaten. The point here is that some pathogenic organisms are capable of thriving inside the modern food system in part because of our reliance on technologies that mask rather than eradicate the possibility of contamination. *Listeria* survives freezing, vacuum-packing, most forms of pre-retail cooking, and different methods used to extend the shelf-life of packaged foods (British Advisory Committee on the Microbiological Safety of Food 1992). University of Georgia researchers suggest that *Listeria* is particularly capable of flourishing in processed poultry (Glass and Doyle 1989).

2. The increased incidence of foodborne diseases has, in part, been facilitated by the timing and decision-making habits of those in the food industry regarding control of contaminating agents.

As value-added production proliferates opportunities for dangerous pathogens to reach the consumer, it becomes extremely difficult to answer effectively the practical question of how and at what point in the production process to control for contamination. Generally speaking, the food industry isolates its efforts to control contamination only during the latter stages of processing, or even waits until the product reaches the marketing stage. The most frequent approach involves washing the food itself and the areas in which it is processed. But as University of Minnesota researchers have pointed out (Raloff 1996), most work surfaces (whether at the processing plant or in the consumer's kitchen) are coated with a "biofilm" of agents resistant to normal water sprays or detergent cleansing. Adequate removal of the biofilm requires use of harder abrasives and longer rinsing than most households or industries are willing to afford. For that matter, high-pressure hoses can inadvertently facilitate pneumonic transmission of such pathogens as *Listeria*.

Clearly, waiting to deal with possible contamination during final processing or cleaning of equipment is not only insufficient, but also potentially counterproductive. Worse still, the modern food industry is so complex that food safety can become an issue in unexpected places, beyond the farm, the processing plant, the supermarket, or the consumer's kitchen. The story of *Salmonella* poisoning of Schwan's ice cream products in Minnesota in 1994 is instructive on this point (Fox 1997, pp. 173-177). While health officials were able to quickly identify Schwan's products as the source of infection, the explanation for why this should have been so was at first a mystery since *Salmonella* is an egg-based disease and Schwan's does not use eggs in its ice cream. As it turned out, the company had subcontracted the shipping of its ingredients to a trucking firm which, in order to avoid the expense of driving trucks empty after deliveries were made to Schwan's plant in Marshall, Minnesota, engaged in the customary practice of "backhauling." Several trucks involved had backhauled contaminated eggs between trips to Marshall, and even those vehicles which had been subjected to normal cleaning procedures still contained *Salmonella*-coated surfaces.

Changes in agriculture have affected food safety issues on the consumption side of the equation as well, where there are at least two dimensions to note.

1. First of all, the public is not well informed and yet is frequently blamed for food safety crises (Mueller 1990).

Quite often industry experts, health officials and government agencies wait to address food safety issues only after a disease outbreak, and then frequently respond by shifting blame to the consumer. In this scenario, responsibility for food quality has more to do with preparation than with production or processing. The role of institutions in this scenario needs careful examination. Nichols Fox provides an instructive example of government response to *E. coli* outbreaks in fast food and school lunch materials in western states (1997, p. 343):

> "The USDA conducted a study in 1993 to determine the most effective way to reach the public with consumer information. The study revealed, not surprisingly, that television was the most effective, radio a close second, and pamphlets the least effective. With fascinating logic, the USDA then decided to use the pamphlet approach to 'warn' the public about the potential for pathogens in raw animal products. [A major industry organ, the] Food Marketing Institute assisted the agency in designing the brochure [and a postcard]...revealing in glowing color the dual and conflicted role of the agency. On one side was a beautiful hamburger with all the trimmings- a meat promotion, if ever there was one....The safe-handling information that follows is sound advice, but...there is no mention of *E. coli* O157:H7, no mention of the western states outbreak, no mention of the possibility of serious illness or death...The USDA announced this postcard campaign with great fanfare. What it neglected to mention in the photo-ops was that the cards would not be sent to schools automatically. School nurses would have to ask for them."

2. The food industry, especially in the U.S., has moved to gag criticism of the conflict between its search for profits and its inadequate approaches to assurance of food quality and food safety.

Consumer groups have formed in response to the increasing number of food-related medical emergencies. Examples include Mothers and Others for a Liveable Planet (Garland 1993), Parents For Pesticide Alternatives, Food & Water, the Safe Food Coalition, and Safe Tables Our Priority (STOP). Many of these and similar organizations are working for legislative changes in the way food is produced, processed and marketed. Other groups have chosen to forego the effort of confronting a politically resourceful and globally organized food industry to focus on promotion of nutritional issues at the local and regional level (Webb *et al.* 1998). At the same time, the food industry has tried to assess public perceptions of changing agricultural technologies (Van Ravenswaay 1992 and 1995).

In the U.S., industry has also responded to consumer concerns by pressuring legislatures to test the limits of freedom of expression, prodding 13 states into passing "agricultural disparagement" laws (Fox 1997, pp. 339-342). Heavily promoted by the American Feed Industry Association and the American Farm Bureau Federation, such laws allow farmers, growers and food industry groups to sue anyone who slanders the reputation of their products. Following the 1989 scare about carcinogens used in a chemical called Alar to produce high quality apples in Washington State, anyone trying to raise public consciousness about food safety issues must be able to back up their claims in court scientifically. But the question of scientific determinations of safety is never easy to answer. In 1985, the Environmental Protection Agency claimed that Alar was likely to cause one extra cancer death per 10,000 individuals, but in 1989 EPA lowered its estimate to 3.5 per 100,000 persons. Tire manufacturer Uniroyal, not normally associated with the food industry, makes Alar. The company resisted EPA requests to voluntarily remove the product from the market (Waltner-Toews 1992, pp. 87-88). Needless to say, most consumer groups do not have the financial resources sufficient to enable adequate scientific study of food quality even as citizen radicalism increases (Goldstein 1990). The story of Alar and apples should not be considered in isolation, but taken as an example of general trends. Public concerns about such issues as health risks from pesticide residues on ready-to-eat fruit and vegetables continue to draw attention to the impact on food demand (Van Ravenswaay and Hoehn 1991; Wiles and Campbell 1994).

Overall, literature dealing with foodborne diseases tends to focus on health issues exclusively, with little emphasis placed on social impacts (see for examples Bellenir and Dresser 1995; Cliver 1990; Hubbert 1996; Miller, Smith and Somkuti 1990). This is not to say that there is no literature which comes closer to addressing issues of socioeconomic foundations of a modern food system that unintentionally supports the transit of pathogens from farm to table. But such material is either of a more sensationalist variety or takes the form of miscellaneous government publications (Fox 1997; Nagy, Nurmi and Mulder 1996; Roberts, Jensen and Unnevehr 1995). Meanwhile, the USDA's Food Safety and Inspection Service maintains an online newsletter called "The food safety educator" (http://www.usda.gov/agency/fsis/educator.htm). A more academic literature pays attention to issues of food safety policy (Fisher 1992). In all cases, broad access to timely information increases both the perception and reality of a safe food supply.

3b. Treatment of Animals and Ethics

Concern for farm animal welfare has been voiced at various times in the U.S. since at least the 1870s, but contemporary legislative reform surrounding the issue has been much more actively

pursued in Europe since the 1980s (Guither and Curtis 1983; Baumgartner 1993; Rowan 1989). In general, literature dealing with the treatment of farm animals most frequently takes a global perspective or by contrast focuses on particular species (Council of Europe 1991b and c; DeLind 1995; *The Economist* 1996; Faramelli 1981; Fölsch 1978; Mepham 1996). In the emerging era of cloning, a rapidly expanding literature emphasizes the issue of scientific ethics and government policy as regards food production (Halweil 1998; LeMay 1988). Particularly in Europe, where economic integration is focusing more and more attention on the quality assurance practices of different producer-nations, there is increasing attention to the use of genetically-modified organisms in agriculture (Oleagineux Corps Gras Lipides 1998).

Having focused on laboratory animals and endangered wild species, animal-rights groups are increasingly turning their attention to the welfare of on-farm animals. But here, too, the literature deals with general issues of public policy rather than on specific cases or community impacts (Johnson, D. 1998; Ohlendorf, Jenkins and Tomazic in press; Rollin 1993; Spira 1996; Thompson, Matthews and Van Ravenswaay 1994). In Germany in the early 1980s, "5% of the egg producers owning between 80 and 90% of the hens [were] able to gain a competitive advantage, as cruel forms of management...enabled them to produce more cheaply" (VonLoeper 1985, p. 155). Von Loeper also suggests that EEC (now EU) directives do not necessarily "constitute an advance in those member states which have animal protection laws worthy of the name; on the contrary, it creates the danger that all the systems will be brought down to this minimum level" (1985, p. 153). Closer examination of the issues will likely require study of particular groups working to effect change, as well as careful consideration of what constitutes adequate 'animal welfare.' At least one study (from Austria) has discussed the implementation of an "Animal Needs Index" (Bartussek 1997). In this regard, while writing about growth promoters in cattle and the possibility of enhanced meat as a potential health hazard, Boone (1993) provides addresses of activist organizations in Belgium and elsewhere in Europe.

According to Jasper and Nelkin (1992, p. 141; see also Rowan 1989), a partial list of U.S. groups working to reform the welfare of farm animals includes the Animal Liberation Front (ALF), the Farm Animal Reform Movement (FARM), the Food Animals Concerns Trust (FACT), the Humane Farming Association (HFA), Chickens Lib, and Humans Against Rabbit Exploitation (HARE). An unpublished survey conducted by the Animal Industry Foundation in 1989 suggests that nearly 80 percent of those polled support current practices of farm animal treatment (reported in Ohlendorf, Jenkins and Tomazic in press). But the same survey revealed that two-thirds of those polled are in favor of increased regulation of production practices. Following up on this data, Ohlendorf et al. asked more than 2,700 consumers whether they agreed or disagreed with the statement "I would be willing to pay more for meat if it meant more humane treatment of farm animals." While 23 percent of those surveyed were undecided, one-half of all respondents agreed with the idea of paying more for animal products raised more humanely. There is no significant variation in agreement with this more pro-animal attitude across economic classes. Although Ohlendorf et al. do not address it, this is at odds with the notion long expressed that consumer concern is more likely to be expressed by those with greater financial means. Put another way, the poor have been held to have less concern with how food is produced since they face greater challenges in securing access to adequate nutrition (Sanur 1982, pp. 236-239). Perhaps not surprisingly, Ohlendorf, Jenkins and Tonazic report that those who are least likely to be willing to pay more for meat that is humanely raised include political

conservatives, those with farm experience, the elderly, rural residents, and those living in the Midwest.

But it would be wrong to assume that a clearly definable relationship exists between public perceptions of animal welfare and changing animal agriculture practices. There are regional differences in perception, for example. A 1988 Massachusetts referendum on potential farm animal care regulations received a less than enthusiastic response, as only 29 percent of those voted that regulations should be imposed (Shurland 1990). By contrast, a law passed the same year in Sweden required that cows, pigs, and animals raised for fur be raised "in as natural an environment as possible" (Budiansky 1992). Vegetarianism and animal rights concerns are not identical. One survey revealed that, while 80 percent of those responding believe that animals have rights, 85 percent of the same population believe that it is not wrong to kill animals for food (Rowan 1993, Wirthlin Group 1989, *Parents Magazine* 1989).

3c. Consumer Need to Know about their Food Supply

Shepherd and Sparks (1994, p. 206) helpfully point out that all too often an assumption is made "that knowledge affects attitudes which in turn influence behavior, and therefore changes in behavior can be brought about by increasing knowledge." But it is important to report that meta-analysis of studies relating knowledge to dietary intake showed only very small association between attitudes and behavior and between knowledge and behavior (Axelson, Federline and Brinberg 1985). In other words, while certain segments of society might organize around food issues in headline-making efforts, the average consumer is slow to change habits even when knowledge is broadened (Harris 1988). In any event, first and foremost knowledge of food supply issues has to be placed in the context of lost contact with the realities of production, and an ongoing loss of contact with our local, cultural, historically situated realities of consumption.

> "[Where] we might once have herded our own goats or bent over our own paddy-field, different people now sow the wheat, build the tractor, design the ball-bearing assembly, teach the engineers... [For that matter, first] it was agriculture that was industrialized; then, late in the nineteenth century, food processing and retailing; and finally, since the Second World War, cooking. That is, the household has successively lost its own self-sufficient garden, its cellar or pantry for storage, and now its kitchen." (Symons 1993, p. xi)

There is a literature that documents lobbyists (both corporate and citizens) work to intervene in agricultural policy or other food-related legislative issues (e.g., domestic food stamp and overseas food aid programs). The activities of such traditional producer advocates as those for tobacco, cotton and peanuts have been followed, as have the efforts of the Farm Bureau, the National Grange, and so on (Guither 1980 and 1982). But it is worth noting that most of this literature has focused on agricultural interests, while the efforts of activists concerned with wilderness issues, energy production, and the like also are interested in animal production issues.

The USDA publishes a "citizen's guide to the American food and fiber system" (1985), but public knowledge of food supply is conditioned by more than official documentation. A major obstacle in the consumer's path to improved knowledge about the supply of food available has to do with the creation of brands. A common refrain from marketeers is that the association of a particular type of food or set of food types with a given brand is part of an effort to deliver

consistent quality (Doyle 1990). But there are also issues of economic ideology at work that have more to do with preempting consumer evaluation of a product in order to confirm a sale (Casson 1994).

Dawson (1995) and Slater (1987) focus on the growing importance of retailers as gatekeepers of the food distribution channel in the U.K., with significant impacts on price and product range when producers start assuming more direct control of marketing. Kaas (1993) writes about similarly symbiotic relationships between producers and retailers in the German food market. One effect of increased concentration in the retail sector is the development of both obstacles and opportunities to acceptance of such alternative approaches to food production as organic farming. The ability of ever-larger supermarket chains to out-compete smaller stores in product repertoire means that consumers have fewer choices of where to buy their food.

Under such circumstances, even a more well informed public has difficulty locating alternative products, since the supermarkets are confronted with a labeling problem: "After all, branding one type of food as healthy and ethical does little for the credibility of the rest of their products" (*The Economist* 1997). There are consumers who prefer locally grown, environmentally attractive, and seasonally available foods over those which may be available year-round and grown in a number of locations under varied conditions. But, as in a study conducted in the greater Seattle area (Wilkins 1996), these consumers tend to be food cooperative members or otherwise distinguishable from the mainstream public economically and culturally. Most consumers are not likely to consider regionally-based diets as any more adequate than those based on food produced elsewhere, nor are they likely to regularly buy locally-produced food as a way to conserve natural resources. Generally speaking, with less access to clearly definable alternatives, consumers have not surprisingly expressed an increased demand for prepared meals, even to the extent of Italians expressing an increased preference for frozen pizza (Garbagna 1991; Park 1997; Sloan 1995).

A major change in how retail outlets track purchases and replenish stock also impacts the consuming public's ability to develop broader knowledge of how the food supply is produced, distributed and merchandised. This involves the development in the 1990s of the Efficient Consumer Response (ECR) approach to using state-of-the-art telecommunications (including Internet linkages) to improve any given store's capability to keep its shelves full of items that the public has been successfully persuaded to buy in carefully analyzed markets. According to one study of the changing retail food industry in Minnesota (King, Ashman and Bosley 1998; see also Ashman 1998, King and Phumpiu 1997, and Phumpiu and King 1997), rural supermarkets offer a wider range of products and services than urban or suburban outlets. At the same time, rural stores are proving slower to adopt ECR practices. There is still debate as to which comes first, increased profitability or the adoption of ECR practices, but it seems as though ECR may already have as much to do with creating demand as with its satisfaction. Researchers examining the changing character of the retail food industry note the rise of "grocerants," hybrids of packaged-food and prepared-meal outlets. But at least one study in Minnesota (Larson 1998) notes that the heavy investment many retailers have made in food preparation options have not necessarily translated into increased store profitability.

At the same time, pressure from citizens groups such as STOP and the Safe Food Coalition has provoked a certain amount of institutional change in terms of how government interacts with the

food industry. In 1996, consumer groups were able to celebrate passage of legislation requiring the replacement of old "organolyptic" methods of inspecting food by sight, smell and touch with newer and more intensive methods called the hazard analysis and critical control points (HACCP) system. HACCP is supposed to be a more scientific approach to identification of those moments in the production process when intervention to insure food safety will be required. Supposedly more thorough than previous modes of inspection, HACCP includes such procedural changes as regularized microbial testing.

However, HACCP legislation was not passed without significant issues being left unaddressed. Foremost among these is the fact that, paradoxically, increased government regulation in this case means devaluation of the role historically played by the USDA, since HACCP monitoring will be primarily carried out by food producers directly. Beyond this, other problems plague the HACCP approach. For example, no requirements are yet in place mandating that meat be kept chilled during transport, let alone specifying a maximum temperature at which food may be kept refrigerated in order to satisfy demands for safety. Also, inasmuch as the food industry is significantly in control of the HACCP process, the accountability sought by STOP and other groups in the new legislation is not likely to materialize. This is because the inspection reports produced are the private property of the companies involved rather than subject to public access through the provisions of the Freedom of Information Act.

Finally, there is also a basic question of how to define what an appropriate "critical control point" is in any given case, since (as already suggested) the complexities of modern agroindustry mean that there is no single moment when food quality can be entirely assured. This point is emphasized, for example, by the actions of the United Egg Producers (UEP) in its reaction to government concerns about the rising incidence of *Salmonella* poisoning. The 1980s were marked by rising incidence rates of *Salmonella* that USDA eventually confirmed were associated with the growth in flock size among poultry producers (Ebel, David and Mason 1992; USDA 1991). Canadian incidence rates during the same time were lower, as was the average number of animals per henhouse (8,000 as compared to 60,000 on average among major U.S. producers).

Industry response was to pressure for changes in the ways USDA programs received funding. At the start of the 1990s, existing rules allowed the agency to trace back contaminated eggs only if one farm was identified. The UEP quickly realized that if it began a practice of multiple sourcing (ie., having distributors buy from two or more suppliers, each of which had bought from more than one producer), USDA would not be able to regulate the industry in the name of improving consumer knowledge about safe products. Fox sums up the situation by pointing out that "In 1990 the USDA traced 86% of outbreaks back to the source; by 1993 that number stood at a distressingly low 17%" (1997, p. 172).

Comparisons from abroad are worth noting here. Swedish poultry is virtually *Salmonella*-free, Dutch testing for *E. coli* is far stricter than the American standard, and New Zealand has more stringent temperature controls for food preparation and shipment. Steve Bjerklie, former editor of the food industry organ *Meat and Poultry,* criticized the USDA's passing efforts in the early 1990s to put warning labels on meat. Nonetheless, he soon changed his tune, urging the industry to re-think its legal efforts to punish USDA and the Food Safety Inspection Service for broadcasting such notions. Bjerklie (1995) complained that Dutch procedures to test meat for *E.*

coli make the American approach resemble "quality control at the `Laverne and Shirley' brewery."

In general, the EU has more readily accepted the possibility that overuse of antibiotics and hormones in agroindustrial approaches makes livestock more vulnerable to bacterial infections. Especially in the aftermath of the "Mad Cow" crisis in Britain, the European Union has responded to increased consumer interest in the origins and quality of its food by formulating a set of Common Agricultural Practices (EU Social and Economic Committee 1996). Most importantly, the CAP guidelines deliberately take aim at reduction in the number of animals housed in any given operation, as well as encouraging EU members to switch to more extensive (organic or "biologic") farming methods. Sweden, Denmark and Germany all plan to implement organic farming on at least 10 percent of their arable by the turn of the century. The EU has also put into place a "Third Country Meat Directive" which, while it makes exports of U.S. products to Europe more difficult, has been credited by at least one industry insider as "the best thing ever to happen to U.S. plant design" (Bjerklie 1995, p. 54).

By contrast, the trend in the U.S. is for the food industry to emphasize technological solutions to HACCP-identified problems (Hoban and Kendall 1992). This further intensifies an already intensive food production value chain. Rather than move toward significantly more extensive forms of production, continued concentration of resources amounts to what Waltner-Toews (1992, p. 161) calls "Stalin's Victory, or the Bulldozer Solution, since it promotes centralization in both the private and public sectors." Under such circumstances, consumer knowledge of food supply becomes an inaccessible issue, even as it becomes a more important component of future dietary decision-making.

Availability of information not only affects consumers' ability to make informed food choices, but unequal access to information has been hypothesized to influence how vertical integration has take place in the food industry (Hennesy, 1996). Information availability – both in terms of what is gathered and what is accessible – is critical for consumers to know their food supply.

3d. Consumer Demand and Willingness to Pay for Food as well as Externalities that May Result from Production of Animal Products

There is a large and detailed literature dealing with consumer food preferences and food price and demand studies. However, while it is widely understood that social and cultural influences play at least as much a role as economic considerations, existing research generally evaluates the impact of food choice on the individual or on families rather than on communities at large. Where the unit of analysis is larger than the household, an anthropological emphasis is often placed on the cultural definitions of food quality, the additional costs associated with appropriate preparation, determinations of who eats what under varying circumstances, and so on.

It is worth mentioning that there were studies dealing with specific foods or elements (salt, fat, etc.), but researchers frequently emphasized the proliferation of food options available in the contemporary supermarket. Importantly, such developments mean, "consumers are becoming more dependent on nutritional value decisions that are made for them, not by them" (Emmons 1977, p. 41). Under such circumstances it becomes harder to discern the impact of agricultural restructuring on any given community. This is especially true when local practices and habits of

evaluating food choice options are entangled with state and federal policies dealing with agricultural production, processing and marketing, not to mention policies dealing with exports and imports, taxation, and general economic development planning. The net effect of such de-emphasis on the local community is to create a "national nutrition environment" (Emmons 1977, p. 41). Consumers make food choice by acting within a web of relationships including producers, processors, retailers, government, educational institutions, the media, and even the catering sector (Hurren and Black 1991). As Anderson, Milburn and Lean (in Marshall 1995) suggest, these "meshes of a net are interconnected and a pull on one will affect the shape of all." Thus, even if consumers express a willingness to accept certain externalities in order to select the food options they desire, the consequences of doing so may not be properly understood, especially if they are manifested in ways which do not immediately appear to have any obvious connection with food supply.

Nonetheless, consumers can have significant impact on food markets, not just in response to crises, but also as concerned citizens willing to pressure their governments for more stringent control of production techniques. As previously indicated, significant food safety issues are raised by the orientation of the contemporary system of value-added agriculture toward answering market demand for ready-made food. It is therefore necessary to appreciate something of the complexity involved with contemporary food culture, both in the United States and abroad. A Norwegian project (AIR-CAT 1996) has extensively explored consumer attitudes toward meat in France, Germany, Ireland, Italy, Spain, and the U.K For example, studies have been conducted looking at consumer attitudes toward retailing of sliced cooked ham as compared to traditionally-made hams, and likewise at consumer perception of prepared ground meat dishes.

One example of consumer impact on food markets was demonstrated in Sweden in 1987, following discovery that much of the chicken supply was infected with *Campylobacter,* a microorganism capable of causing infectious diarrhea and prolonged fever, with several different possible outcomes, including for example, progressive paralysis. Almost immediately poultry consumption dropped 40 percent (Fox 1997, p. 197), and citizen action prompted significant overhaul of Swedish poultry production (RIVM 1994). Flock size was reduced, a number of hours of open-air or `free-range' time has been mandated for animals, and so on. The new Swedish rules assume that confinement of mass numbers of animals increases the stress experienced by individual birds and thereby increases the amount of infected litter and other housing surfaces (rafters, lighting fixtures, etc). Building on the Swedish experience, the European Union is beginning to establish poultry production guidelines for all member states that emphasize limited flock size and open-air time (Commission of the European Communities 1996).

Two significant opportunities for infection are largely bypassed by the changes that regulation has put into practice. First the Swedes practice an "all-in, all-out" regimen of removing all litter and disinfecting all equipment and premises between use by different flocks. In the U.S., producers tend to wait longer before cleaning out a facility, thereby potentially exposing untainted flocks to infectious agents left behind by animals already removed for slaughter. Second, animal welfare regulations in Sweden reduce stress in individual animals and therefore improve the consumer's chance of buying an uninfected animal. Provisions are also made in these regulations for the continued feeding of animals scheduled for slaughter, the consideration of animals comfort during transport, and the minimal use of antibiotic therapies (Council of

Europe 1991a). By contrast, American production techniques typically include withdrawal of food from animals ready for slaughter as a way of keeping costs down. Moreover, antibiotics favored by major U.S. producers are those to which *Campylobacter* is resistant; in effect, producers are unintentionally increasing opportunities for one kind of infection while trying to forestall others such as *Salmonella* (Fox 1997, pp. 198-199; Blaser 1996).

Macfie and Thomson (1994) brought consumer science professionals together with psychologists and extension services personnel to report on various ways to measure food preferences. A standard approach to modeling food choice, they suggested, is to rely on the theory of "reasoned action," in which the consumer is seen as making rational decisions with complete autonomy from other forces. But others were careful to point out that there are a wide variety of factors influencing the consumer's choice of food (Shepherd and Sparks 1994).

Kahn (1981) broadly categorized these other factors as follows:

Intrinsic factors include the appearance, odor and flavor of food.

Extrinsic factors include exposure to advertising (Rickertsen 1998b), the consumer's situation with regard to local merchandising arrangements, and seasonal variation in food supply (Arnade and Pick 1998; Johnson, A.J. 1998).

Personal factors include level of expectation about supply and quality of food, familiarity with alternatives, and so on. Echoing trends in America, a National Food Survey conducted in the U.K. (MAFF 1994) indicates that 35 percent of all food purchases are ready-made meals. At the same time, however, only 20 percent of those responding to a London Food Commission survey were willing to accept the possibility of fast foods as "good for your health" (Carruthers 1988).

The consumer's educational status, awareness and valuation of nutrition information, and age, sex, and other biological and psychological factors can further influence these personal factors. Focusing on the impact of socio-psychological factors on food demand emphasizes a need to look beyond demographic characteristics of consumers (Bayton 1977). This is because variance in psychological attributes among sets of consumers can complicate the assessment presented only superficially by demographic data. Thus, it is possible that a given community has structured needs, preferences, and expectations regarding food supply regardless of the differentiation of its population by economic class, educational attainment levels, and so on.

Socioeconomic factors include consumer income, the cost of particular food items, and the relationship of consumption patterns to social status (Jones 1997; Park 1996). Changes in affluence can significantly affect food demand patterns (Chaudhri and Timmer 1986). On the other hand, price elasticity data from the U.S. and U.K. for certain products (for example, meat and poultry) indicate strong substitutability, suggesting less discrimination between product categories than is sometimes imagined (Senauer, Asp and Kinsey 1991; Chesher and Rees 1988; Ritson and Hutchins 1995).

Also, it is important to consider cultural factors when modeling food choice (Eales, Durham and Wessells 1997; Rickertsen 1998a). These can include the ethnic and religious background of consumers, as well as the symbolic meanings that such background associates with food types and consumption behavior (from purchase of food through to decisions about how much to dispose of and in what manner). Sanjur (1982) also writes about social and cultural perspectives in nutrition, exploring dietary patterns among different ethnic groups in the United States (see also Goodwin, Holcomb and Rister 1997).

It is important to consider cultural factors in a geographic context. What region of the country a particular household is located in can have considerable bearing on what types of food are consumed, what brand names are typically available, and so on (Bacon, Gempesaw and Handy 1989). Also, the relative homogeneity or heterogeneity of local cultural circumstances may influence household consumption patterns. Consumers living and working in communities of cultural backgrounds different from their own may feel pressured (socially as well as in terms of food supply and demand) to mask their own preferences. On the other hand, this may be more indicative of the particular situation faced by ethnic minorities in a pluralistic society such as the United States. For example, there is no doubt that globalization is changing the nature and increasing the extent of contact between American producers and Asian food consumers. But two studies conducted by sociologists at Washington State University (Jussaume and Mtika 1994; Jussaume and Lin 1996) caution that despite the emphasis placed by factory farms on producing for Pacific Rim markets, little direct evidence exists to indicate significantly increased demand for American products. Traditional dietary patterns overseas remain largely unchanged, suggesting that increased production will have to find non-food markets for animal agricultural output. Even in Japan, where the adoption of Western food has symbolic importance, sociological factors driving the decision to buy American beef are not necessarily supported by economic considerations framing the decision to continue such purchases regularly (Sapp and Jensen 1997).

We must understand how important it is to produce a differentiated product in terms of the stages in food consumption. In low-income countries, food consumption is solely to meet caloric needs and to produce more, particularly more grains and pulses. This plight describes the situation today in much of Africa.

In medium-income countries, the strategy changes. Pulses and grains are supplemented by increased diet quality, generally defined as eating more meat and dairy products. Thus, medium-income countries are interested in eating more meat, sometimes in importing more meat, and often in raising more meat.

In high-income countries, which influence the bulk of world trade, people seek a differential diet. They look for multiple characteristics in the food they eat. Unfortunately, for many cooperatives, the strategy for production is still either in the low-income or medium-income stage: produce more, first of grains, then of meat. Yet, if coops are going to have the number of owner/members necessary for long-term survival and sustainability, it is critical to look at the high-income, differentiated product solution.

What is clear is that in the second half of the 1990s, consumers in the U.S. (and the U.K.) have more per capita disposable income available at a time when expenditure on food has fallen from about 20 percent to 12 percent since the early 1970s (Hughes 1994; Putnam 1990). The trend, here and in Europe, is consumer movement toward better quality food and value-added products (Thompson 1991). Poultry, an increasingly important component of the Minnesota agricultural sector (Morse), is substituted for red meat more frequently than hitherto, as are vegetable oils for animals fats and skim- or semi-skim milk for full-fat milk. But even as the consumer trends indicate a search for a healthier diet, they also emphasize entrenchment of a culture of convenience. American consumers choose processed fruit juices more readily than fresh fruit (Senauer, Asp and Kinsey 1991). Moreover, fewer meals are eaten at home, and retailers have seen a dramatic rise since the 1970s in the number of consumers buying time-saving kitchen equipment (McKenzie 1980).

Any effort to understand the impacts of changing agricultural practices on a particular community is likely to fail without adequate appreciation of the increasingly globalized culture of food consumption. Postcolonial and post-Cold War Europe is experiencing an intensification of cultural pluralism demographically and politically. These changes (for instance, the immigration of large numbers of South Asians into England) make for new eating options for a population with more money to spend on food and a preference for having its meals prepared in advance. Similar changes are taking place in the U.S. and elsewhere as consumers say goodbye to "culinary cringe" (Ripe 1993). For example, Crandall (1985) writes about the adoption of doughnuts as a regular part of the diet in fishing villages in Alaska. Likewise, demand now exceeds supply in the United States for bison as a high-protein, low-fat, low-cholesterol substitute for beef (*The Economist* 1994).

But the "unmanageable" consumer (Gabriel and Lang 1995) may be making demands for variety and accessibility produce opportunities for food producers that are at odds with the parallel trend in growing consumer concern about food quality (Gofton and Ness 1991). A team of Minnesota Health Department officials (Hedberg, MacDonald and Osterholm 1994) have emphasized the impact of free trade agreements such as NAFTA on the possibility of increasing already significant imports of fresh fruits and vegetables from Mexico, Central America and other tropical areas. They point out that these are parts of the world where environmental regulation and an infrastructure supportive of high-quality food production are both largely absent. Nonetheless, as more American consumers search for exotic foods or simply year-round supplies of preferred items, they are creating opportunities for encouraging unsafe imports. The food industry responds by adopting new technologies of food processing, like irradiation.

But analysis of willingness to purchase and pay more for such products at best suggests how problematic it may be to arrange many different economic, cultural, regional and other populations together under the all-inclusive label "consumer" (Malone 1990). For example, there is evidence to suggest that stated preference for family consumption of low-fat foods does not match up with actual consumption patterns (Weidner, Archer and Healy 1985). Matters are made all the more confusing by the fact that the consumer is not a fixed entity, but is metamorphosing over time (Doyle 1989). Overseas, there is evidence that consumers are willing to pay more for safer food. Dr. Eva Berndston of the Department of Food Hygiene at the Swedish University of Agricultural Sciences in Uppsala points out that chicken is priced at about $2.20/pound there, while U.S. supermarket prices hover around $1.00/pound. But others point out that since more

chicken is produced in the U.S., consumers here have little incentive to engage in citizen action "to reduce the level of a pathogen [they have] never heard of" (Fox 1997, p. 200).

Thus, on the one hand, lower prices resulting from better availability of a product can have a braking effect on citizen concern. On the other hand, mass production of animal products might generate a willingness to absorb higher prices at the checkout stand. An instructive example can be found in pork production, which accounts for 30 percent of all agricultural marketing in Iowa. There, as elsewhere, a profound structural change has taken place as an increasing number of "factory farms" of 1,000 head of swine or more are rapidly taking commanding positions in the industry. There are at least three consequences of this situation.

1. A loss of smaller family farms that cannot compete with the new industrial operations.

2. An increase in environmental degradation as a result of the shift to factory farming with large inventories of swine.

3. Some recovery of Iowa's cost competitiveness as a hog producer.

Despite growing concern about negative community impacts, the last effect still tends to have more political significance than the first two. A study conducted by the Leopold Center for Sustainable Agriculture at Iowa State University (Kliebenstein and Hurley 1999) confirmed that once informed of the environmental attributes associated with pork products, 62 percent of those surveyed said they would be willing to pay more for their food if it costs more to produce it in an environmentally-sound manner. Participants in the study were willing (on average) to pay 94 cents more for the most environmentally attractive two-pound package of pork loin chops (about a 22 percent increase in price at the supermarket). At the same time, once informed on how the "typical" product is being produced, those surveyed said they were unwilling to continue paying current consumer prices. The typical package decreased in price by 52 cents on average (a drop of more than 12 percent). This willingness to pay more for environmentally attractive products ties in well with the evidence presented earlier that consumers are also willing to pay more for food produced with greater attention to animal welfare. It is important to note that those surveyed by Kliebenstein and Hurley were not only Midwesterners, but included participants from North Carolina and Oregon as well.

SCOPING DOCUMENT QUESTION 4: WHAT MECHANISMS ARE AVAILABLE FOR PRODUCERS AND THEIR NEIGHBORS TO RESOLVE PERCEIVED PROBLEMS RELATED TO ANIMAL AGRICULTURE IN THEIR COMMUNITIES AND HOW EFFECTIVE ARE THESE MECHANISMS?

Community and neighborhood conflicts in the context of agricultural restructuring, including animal agriculture, are slowly emerging in the literature (Grey 1995). There are fewer systematic studies of strategies for conflict resolution in communities impacted by animal agricultural restructuring processes. Some studies have addressed conflict coming from social change processes in rural areas. One case study, for example, explored similarities in the nature of conflicts that arise in gentrifying neighborhoods and rural counties in the wake of rapid in-migration (Spaine 1993). The basic thesis is that as newcomers move into established

communities and neighborhoods they generate a critical mass of people with greater access to resources than long-term residents. Privatization of previously public goods (access to) often accompanies this redistribution of resources. The study showed that conflicts over resource allocation and utilization that result are often clothed in the language of different values regarding the community's identity.

Although the study does not address neighborhood conflict in the context of agricultural change, the issue of neighborhood problems in the face of demographic transformation as new social groups move into a community can be viewed as instructive for animal agricultural systems. The increasing number of minority laborers moving into rural communities surrounded by factory type animal facilities has emerged as an area of conflict in recent years. Studies have focused less on ameliorative strategies and conflict resolution alternatives than on documenting conflicts (Grey 1995). This study suggests that where there is substantial in-migration of former urbanites and immigrant labor as animal production systems increasingly industrialize, conflict over basic environmental attributes is unavoidable, which obviously calls greater attention to the challenge of creating the social resources necessary to resolve such problems in a community.

Margolis (1992) explicitly explored the nature of neighborly relationships and the boundary problem that exists with environmental elements that are "unbounded," like sound and odor. Exploring how sound (in this case) can be used to claim physical space and establish social boundaries among neighbors, three types of social action were suggested—civic accommodation, status mapping and placing. Because a person cannot inexpensively move from the neighborhood being invaded by unpleasant noise or odor caused by a neighbor, conflict is likely to result (Couch 1989).

Farmers are disadvantageously placed due to their increasing minority status in many rural areas compared to newcomers. They take action to change their mode of production and also to claim their place in an evolving social structure. This is due to their relative inability to move their operations to another, more isolated location. Their ties to the land they own and the locality in which they have invested a lifetime of experiences are strong, ties they are unwilling to break.

This civic pattern or context for conflict resolution acknowledges that there are situations in which there is no individual possession, where "...resources are social, constructed as community possessions and the value of the commonwealth is expressed in its condition."

One person cannot behave in one pattern when another person is behaving in a second and expect to arrive at a satisfactory resolution. In other words a conflict created in the civic context—disputes over the commons—cannot be satisfactorily resolved by market forces and exchange of values. Social capital – a community resource that can mediate intra and inter group collaboration, and interpersonal support in reaching consensus – is critical in such instances.

A study in Northern California explored how ranchers (neighbors) settled disputes about the use of an open range when cattle strayed from public to private lands causing damage to fences, crops, property, etc., or got mixed with other herds injuring each other, and other forms of "damage" (Ellickson 1991). This situation parallels that of the "commons" widely used in environmental studies.

People often choose informal custom over law because custom tends to be administratively cheaper (involving lower transaction costs) and customary rules are more likely to be welfare maximizing. These norms cover a wide variety of situations and can be complicated in their relationships. A theory of norms "designed to illuminate in what social contexts and with what content informal norms emerge to help people achieve order without law" was proposed (Ellickson 1991).

Ellickson's hypothesis is that: "members of a close-knit group develop and maintain norms whose content serves to maximize the aggregate welfare that members obtain in their workaday affairs with one another." (Emphasis added.) The underlined text refers to ideas that seem particularly relevant in the context of the rapid industrializing process underway in the animal agriculture sector. Given the demographic changes in many rural "neighborhoods"—a relatively unresearched concept—many localities may no longer feature "close-knit groups" in which informal power is broadly distributed among group members and the information pertinent to informal control circulates easily among them. The author also used the term "durable social networks" to refer to close-knit groups and argued that "welfare" must be measured by objective values, not subjective utilities, because this norm is often enforced by third party controllers based on desired outcomes (e.g., the state).

The author noted situations in which neighboring norms were likely to be ineffective. First, the size of the stakes matter. When stakes are small, disputants are less likely to regard the relatively high administrative costs of the legal system to be worthwhile. The substantive content of the dispute also matters as legal and informal control systems vary in their ability to handle technical complexity. Members of a group can be expected to "choose the controller that best enables them to externalize the costs to outsiders." Referencing what prior investigators had found in other contexts, the author concluded, "disputants are increasingly likely to turn to legal rules when (1) the social distance between them increases, (2) when the magnitude of what is at stake rises, and (3) when the legal system provides an opportunity for the disputants to externalize costs to third parties." For lawmakers, the study suggests that those who are unappreciative of the social conditions that foster informal cooperation are likely to create a world—or try to do so—in which there is "more law and less order."

Using a survey methodology, a study in Belgium looked at a resulting conflict when a plant was located in one community (Langenhove, Lootens and Schamp 1988). Inquiry forms were distributed in the neighborhood of a rendering plant and in a reference area in Belgium. Using simple statistical calculations it was shown that there was a significant difference between responses from both areas. More detailed analyses of results as a function of the distance from the source revealed that the presence of the odor source resulted in significantly different responses up to a distance of 600 meters from the source. Furthermore, it was shown that inquiry results were not much influenced by respondents' attributes such as gender, age, etc. Age and time of living in the neighborhood were significant parameters for spontaneous complaining to local authorities.

A study of inter-group conflict in heterogeneous neighborhoods (urban) explored the identification of factors contributing to real-life conflict in neighborhoods undergoing in-movement of new groups (Lawrence, 1995). The study used a comparative methodology of matched neighborhoods that differed primarily on the presence of violent conflict. Six factors

that appeared to operate to affect the level of conflict other than increased neighborhood diversity were identified: (1) local sense of community and patterns of interrelationships; (2) experiences with power and control over local housing resources; (3) organizational mechanisms for dealing with conflict problems; (4) the nature of the role played by local leaders; (5) the role of city government leaders; and, (6) local informal processes of social control. The study appeared to contradict the common notion that increasing heterogeneity of population in neighborhoods meant increasing frequency and level of conflict.

There are no systematic, comparative studies showing dispute management. A national Extension team, partially supported by the NCRCRD, is currently gathering general case studies on community conflicts. Five of the 23 case studies involve confinement agriculture conflicts. Robert C. Koehler of the Minnesota Extension Service wrote a Community Relations Module based on the work of Peter Sandman, the Iowa Peace Institute, and the work on Conflict Transformation to show how the public responds to the issues and how to do a good neighbor community relations plan. The Environmental Assurance Program has been widely distributed by the National Pork Producers Council, but there has been no follow up on its effectiveness. The goal has been to avoid conflict by creating understanding and communication to work out problems. The assumption is that the best way to avoid or resolve conflict is to work one-on-one with one's closest neighbors. That conflict resolution model assumes an owner/operator who lives on farm or at least the local community.

There are a number of models of conflict resolution and avoidance regarding animal agriculture that are currently being implemented in Minnesota. Systematic study of the contexts in which they occur, including the participants, with special attention position within the structure of agriculture and local versus in-comer status, the processes implemented, and the outcomes for the communities involved would help inform actions of public and private groups. Dukes (1996) argues for more systematic application of public conflict resolution by policy makers to confront disintegration of community, alienation from government and the inability to solve public disputes. He makes a strong case on how to build a practical foundation for a transformative practice of dispute resolution that can inspire and nurture community. Since the social science literature suggests the conflicts that accompany the move to large, integrated animal confined feeding facilities, understanding how best to resolve the conflict at the most local level possible seems critical.

3. Conclusion and Recommendations for Additional Research

There is very little systematic evidence of the impact of the structure of animal agriculture and its changes on the social fabric of rural communities. The refereed research to date suggests of number of hypotheses to be tested through systematic research. Such research could provide important input to such administrative and legislative decisions establishing rules and regulations, tax and dollar incentives, subsidized investment in facilities, and appropriate land use. Further, potential consumer and citizen preferences and concerns about meat and animal production could guide such decisions.

Future research should address these major areas:

I. Impact of different structures of ownership and control of animal agricultural production on community well-being;
II. Impact of structures of animal production on household well-being
III. Impact of structures of animal production and changes in structures of animal production on farmers interactions with the community;
IV. Consumer willingness to pay for particular qualities related to the production, rather than the intrinsic qualities, of various types of meat.
V. Citizen propensity to organize to regulate against particular aspects of animal production.
VI. Effectiveness of different approaches to conflict avoidance

I. Impact of different structures of ownership and control of animal agricultural production on community social well being.

There are several dimensions of industrialization of agriculture that can have impacts on the social fabric of rural communities – scale of production, capital intensive technology, separation of ownership from management, patterns of ownership of animals, facilities, and land, division of responsibility for externalities. Some of these dimensions are related, but they can operate independently. Further, the impact will be different if animal agriculture produces commodities (part of a supply chain) or products (part of a value chain).

The impact of remaining part of a supply chain versus becoming part of a value chain is very dependent on who controls the most important links in those chains. Generally, that relates to processing in animal agriculture. There are a variety of ways that communities of interest and of place can change the locus of control and thus alter the social impact. For example, a local locker plant can begin slaughtering and cutting meat bred and raised with more fat than desired in the supply chain for new ethnic markets. A cooperative can organize the value chain. And local governments and local businesses can collaborate to provide housing and other public and private services to new residents, including English as a Second Language for school children and adults.

Research designed to look at the social impact must take into account different types of social organization.

The best way to do this is through comparative analysis. The county is probably the best unit of analysis in Minnesota, because of the availability of data at the county level. Counties should be matched according to the scale of animal production in 1992. Then counties that increased in production could be matched with counties that decreased in production of different animal enterprises. This could be done for hog production, beef cattle production, dairy production, and turkey production – the major animal enterprises in Minnesota. The initial selection would be based on data from the agricultural census. Counties would be matched, based on their distance from metropolitan areas and initial population size. The matches allow comparing counties that increased in production of a particular animal product, but declined in number of farms producing that product, with counties that remained the same or increased in the number of farmers producing an animal product, controlling for distance from the Twin Cities and for population size.

Counties should then be compared on changes in:

1. population size since 1990,
2. gross migration (migrants in plus migrants out),
3. net migration (migrants in minus migrants out),
4. size of different ethnic groups
5. proportion of the population commuting in to work and out to work
6. percent of population in poverty (change in food stamps here would be one potential indicator, as the general tendency of rural people to not seek public welfare entitlements would be controlled by comparing communities to themselves over time)
7. number employed (based on wage data from US Department of Labor)
8. average wage (based on US Department of Labor)
9. change in number of students in local schools
10. change in number of students in special programs
11. turnover in the school system of both students and teachers
12. voter turnout in state and local elections
13. number of seats for local office for which there are at least two candidates
14. number of voluntary organizations
15. number of non-governmental organizations
16. retail operations (as indicated by sales tax licenses)
17. retail sales
18. wholesale establishments
19. attendance at high school sporting events
20. attendance at high school cultural events
21. school drop out numbers/rates
22. student/teacher ratio
23. number of civil suits filed
24. crimes and crime rate by type of crime
25. number of FSA checks that go out of the county (an indicator of ownership patterns)

26. number of meat processing plants by size
27. housing stock
28. housing prices
29. rental prices
30. number of mobile homes
31. number of community events
32. church attendance
33. participation of parents in parent-teacher conferences

The changes over time in these variables should be systematically compared between counties with different structures of animal production. This analysis should be for each type of animal enterprise, comparing consolidated counties with counties where it has not occurred. As this will be different among types of animal enterprises, counties where the processing is locally or cooperatively owned and operated (for example, in Minnesota turkey production) compared to transnational corporate ownership.

The data should be analyzed to determine which of the indicators of community well being are associated with each other and which seem most responsive to changes in the structure of animal agriculture.

II. Impact of structures of animal production on household well-being

A random survey of residents should be conducted in counties chosen for the community level analysis to measure

1. perceptions of health risks related to animal production in that county.
1. trust in institutions
2. perceived quality of friendship relations
3. community identity
4. neighboring behavior
5. attitudes toward cultural diversity
6. times during the year that concerns about air or water quality impacted family and social life, such as gardening activities, cookouts, and parties
7. quality of life, as measured by perceptions of community belonging, usefulness to the community, individual competence, community respect, and sense of alternatives within the community
8. occupations of family members
9. ownership of agricultural land
10. ownership of farm animals
11. if farmer is an occupation of any family member, whether any animals are raised on contract

Initial analysis would compare the residents of communities with animal agriculture consolidation to residents of communities without animal agriculture consolidation. The data should also be analyzed to determine if variation within communities is less or greater than variation among the two types of communities. These data could also be analyzed according to types of animal industry.

III. Impact of structures of animal production and changes in structures of animal production on farmers' interactions with the community

A sample of farm operators (including farm managers) and their households should be drawn from the studied counties. Data would be gathered about their current farming system, with particular emphasis to their animal enterprises and the way those enterprises are structured, particularly in terms of animal ownership and different types of contracts. They would then be asked questions regarding their current participation in the community, including voluntary organizations, local boards, community, church and school events.

The data would then be analyzed to determine if there were differences in levels of participation in different types of civic activity based on a farm operator's position in the structure of agriculture.

This research is probably lower priority than the other two, as the community research would pick up general rates of participation and farmers would be included as potential respondents in the surveys of county residents.

IV. Consumer willingness to pay for particular qualities related to the production, rather than the intrinsic qualities, of various types of meat.

In July, the Hartman Group will publish an extensive study showing different consumer preferences and changes in them between the mid and late 1990s. Thus further consumer surveys will probably not be needed. The major question in fostering value chains is to determine how in Minnesota animal producers get information on consumer preferences and translate them into production and marketing behavior.

Participatory research would be most appropriate in this case. Farmers with different places in the structure of agriculture should be brought together with different parts of the value chain, including consumer groups and grocery stores. The qualities different consumers seek in meat and meat products would be discussed, with the farmers first explaining the qualities they seek to produce in their animal products and which links in the value or supply chains which influence their production decisions. Differences among farmers as they discuss managing the market and managing their resources could illuminate the ability of the consumer to influence both what is produced and how it is produced.

V. Citizen propensity to organize to regulate particular aspects of animal production.

This is another set of questions best addressed through participatory research. Focus groups of environmental and animal welfare activists could be convened to determine their major concerns about meat production and the actions they are considering to address those concerns. The initial focus groups would identify key issues, building on those suggested in the literature review. It would also identify

activists most likely to listen to other points of view in order to gain their ends, rather than having all the solutions in mind.

At the same time, focus groups of animal producers with different positions in the structure of agriculture would be brought together to identify issues that concern them regarding the environment and animal welfare. It is likely that those issues will vary according to position in the structure of agriculture. Once again, the issues would be determined and those most willing to look at alternative solutions to achieving ecosystem health and animal well-being would be identified. In particular, the kind of information the different groups feel are critical in order to make good policy decisions would be discussed.

The two smaller groups would to seek common ground. This is a difficult activity, but an action research activity worth pursuing. It relates closely to the sixth research area. It would suggest areas of where the availability of information for the public should be increased.

VI. Effectiveness of different approaches to conflict resolution and avoidance

The literature review of existing research on these impacts and the methods of conflict resolution being employed to address conflicts over changes in animal agriculture production systems has demonstrated that little specific information is available. What does exist is limited in scope to single instances, to environmental issues different (in specific terms) from those related to animal agriculture, or to small geographical areas. Existing refereed studies rarely addresses the specific problems of changing production systems in animal agriculture and the impact of this change in community and social terms.

Yet a number of "natural experiments" are in place, through Minnesota Cooperative Extension and the Minnesota Pork Producers. To date, no systematic follow-up to determine what actions helps avoid conflict under what conditions and what actions resolve conflict under what conditions has been undertaken.

The relevant research questions appear to be

- What types of avoidance and resolutions methods are used—as compared to those available—and with what frequency?
- What is the effect on the agricultural producer(s), the community where the changes are taking place (neighborhood and broader community), and the jurisdictions in which the conflict is located of the resolution method chosen/employed?
- How effective is each method in producing a satisfactory resolution of the conflict?
- What factors in the situation producing the conflict seem to be most "at issue"—e.g., nature of ownership, land use and private property disputes, technology of production, social factors, economic factors, environmental factors, etc.?

There are a number of specific possible methods of conflict avoidance and resolution that may be identified and used as a framework for future research. These include:

1. person to person: producer to neighbor

2. producer to community
3. collaborative approaches (following B. Gray, 1989)
4. conflict mediation/facilitation/negotiation
5. local regulation changes
6. litigation of disputes/legal action based on local or state regulation
7. legislative action—to create new regulations to address future disputes

These seven categories of possible actions, acknowledged as artificial and frequently overlapping, provide a basic framework for assembling data on specific instances where conflicts over animal agriculture have arisen. Specific "instances" could be generated from a key informant network of researchers, extension workers, the Minnesota Pork Producers and others who follow this issue nationally. Data about each instance—from those states where animal agriculture is a major part of the economy, with a specific focus on Minnesota instances—could be assembled from media reports and key informants. Data gathered about each intervention would include what form of action was taken to resolve the issue, the dimensions of the "issue" as it was perceived and argued by disputants, and the satisfaction of the parties with the outcome. Information regarding perceived outcomes related to the farmers and production system as well as the residual impact on non-producers and community residents would also be gathered.

Some of the kinds of information to be assembled about each instance are:

1. Type of agriculture system proposed—Type of animal agriculture, scale/technology of production, nature of relationships with market, etc.
2. Nature of ownership & control of production management
3. Relationships among producers and neighbors/community residents
4. Historical role of agriculture in locality's economy
5. Civic culture of state/community
6. Legal context—options available for citizens to use in resolving issues
7. Previous experiences re: conflict and collaboration
8. Specific factors central to dispute
9. Demographic change in the locality—immigration of newcomers to community

If resources were available, case studies of exemplary instances could be completed to better understand the (social, political and legal) dynamics of specific resolution processes, specific data on impacts among various interest groups, and the contextual factors involved in the resolution. (It is anticipated that there are two general types of processes that are used depending on the type of producer who plans to site an intensive animal operation in a locality: where the producer is a local family farmer, the process likely begins in neighborly fashion and moves through attempts to "settle the dispute" without recourse to litigation; where the producer is corporate, the litigation process is perceived to be the only avenue of recourse available.)

Research to date shed little light on how the changing structure of animal agriculture affects society in general and communities. Nor does it tell us how different ways of establishing value chains can change the conditions for consumers, communities and agricultural producers.

However, it is possible to design social science research – both traditional research using secondary data, interviews and surveys and action research involving protagonists and focus groups – that can help answer the key questions raised by the Scoping Document and inform public policy aimed at increasing the quality of life of the people of Minnesota.

1. LIST OF MAJOR RELEVANT ON-GOING WORK

Interviews with five researchers conducting key on-going work on social/community changes related to changes in agriculture can be found below, followed by a table featuring relevant on-going research.

DR. MICHAEL SCHULMAN

Dr. Schulman is involved in a study looking at issues of sustainability in southern commodity systems. The research is part of an ongoing USDA Sustainable Agriculture Research and Education funded project and involves collaboration with two nonprofit organizations in North Carolina.

Another major current project he is working on relates to the issue of environmental opposition by community groups in North Carolina. The study specifically focuses on the rise of environmental groups and community opposition to the location factory type hog facilities. His ongoing research also crosscuts the issue of environmental racism as large hog units emerge in predominantly low-income minority communities.

Dr. Schulman is also collaborating with researchers at the school of public health in research on swine odor, and the health implications in communities. A recent major output of that research is a swine odor report that can be accessed from the University of North Carolina research centers web page. While the research is ongoing and no conclusive results are currently available, substantial data is already available and analysis is currently underway. Dr. Schulman also recently collaborated with researchers at the veterinary school in North Carolina and researchers in Minnesota on a "Fund for Rural America Swine Center Project.

Dr. Michael Schulman is a Professor in the Department of Sociology and Anthropology at North Carolina State University, P.O. Box 8107, Raleigh NC 27695–8107.

DR. DOUGLAS JACKSON-SMITH

Dr. Jackson-Smith is involved with a USDA, Hatch-funded national research initiative, otherwise referred to as The National Dairy Community Study. The research is designed to address the issue of structural changes in animal agriculture in relation to its economic and social impacts at farm, community and regional levels. The research looks at the impact of structural change in dairy farm operations and in local communities. Participating states include Wisconsin, New York, Texas, Kentucky, Pennsylvania, Michigan, Utah, Idaho and Minnesota.

Dr Jackson-Smith and other researchers involved in the project are looking at communities and trying to track changes that are going on in the farm sector with connections to community social well-being. While the research is on going and it is too early to discuss findings, preliminary insights suggest that there has been relatively little focus and solid research on the social impacts. The Wisconsin study emphasizes the distinctions between the very large animal operations and the expansion and growth of facilities that have occurred at an intermediate scale. What is more predominant in the Wisconsin dairy sector, initial insights suggest, are the largely

family labor operations that are bigger than they conventionally were, but are by no means industrial farms. Another critical distinction is the relative absence of vertical integration and contracts as social organizational forms in the animal industry.

One of the primary objectives of the study in Wisconsin is to generate information on the situation in Wisconsin and compare that information to other dairy states. The key questions being addressed are, do spending patterns on farms of different sizes change, and to what degree could they be documented? What is the amount of money different size farms spend/invest locally versus regionally and nationally? The research also looks at issues such as the degree of community attachment and involvement, and systematic patterns that emerge as changes in the structure of animal agriculture occur. A key part of the whole research question is whether larger farms are less or more supportive of community than mid-size cow dairy farms.

Dr. Douglas Jackson-Smith is with the Agricultural Technology/Family Farm Institute at the University of Wisconsin, Madison, 1450 Linden Drive, Madison, Wisconsin 53706.

DR. PAUL LASLEY

Dr. Paul Lasley conducts annual surveys of Iowa farmers to address major farm and rural issues. The research is primarily conducted through mailed survey questionnaires to a statewide random sample of Iowa Farm operators. The research issues addressed in the surveys include information technology on Iowa farms, opinions on economic development, ranking of state and national issues, precision farming, farmers' perceptions of quality of life in relation to changes in the structure of agriculture, social issues surrounding the livestock expansion, livestock producers' opinions, manure management and economic impacts of changes in the livestock industry.

Dr. Paul Lasley is a Professor and Extension Sociologist in the Department of Sociology at Iowa State University, 303 East Hall, Ames, IA 50011.

DR. CLARE HINRICHS AND DR. TOM RICHARD

Drs. Hinrichs and Richard are currently involved in research focusing on the socio-technical and environmental dimensions of swine manure management decisions in two watershed regions in Iowa. Their research constitutes interviews with swine producers using manure management systems that encompass the dominant options prevalent in Iowa (i.e. open lot, slurry storage, anaerobic lagoon, deep-bedded hoop structure, and pasture). The main objective of the study is to better understand how farmers in different farming systems view the place of manure- as a waste or resource—and why they view it that way. Results of the study will be used to improve design and implementation of manure management systems that address farmers' needs and also protect the environment.

Dr. Clare Hinrichs is an Assistant Professor in the Department of Sociology at Iowa State University. Dr. Tom Richard is an Assistant Professor in the Department of Agricultural Biosystems Engineering at Iowa State University, Davidson Hall, Ames, Iowa 50011.

Title of Research Project	Principal Investigator(s)	Relevance to the Study Questions under Social/ Community Topic	Status/Expected Completion Date
The Potential of the New Agriculture to Enhance Community Well-being	Gillespie, G. W., T. Lyson and G. Hilchey. Community and Rural Development Institute, Cornell University, Ithaca, New York 14853	Relevant to question 1. Examines and compares the economic and geographic spaces occupied by large-scale agricultural producers, and smaller scale community integrated agricultural entrepreneurs; examines at the community level, the relationships among scale and organization of agricultural production and levels of civic welfare and socioeconomic wellbeing.	Extended
Rural Development Through Environmentally Enhanced Poultry Production	Collins A., D. Colyar and J. Flecher. Department of Resource Management, West Virginia University, Morgantown, West Virginia 26506	Relevant to question 1. The project's objectives are to maintain and improve incomes and the quality of life in rural communities with poultry production and processing facilities.	Active through Sept. 2002.
Commodities, Consumers and Communities: Local Food Systems in a Globalizing Environment	Hinrichs, C. and S. Hendrich. Department of Sociology, Iowa State University, Ames, IA 50011	Relevant to Question 3. The study, among other objectives, assesses how social, economic and political forces influence the interaction between community, consumers and the local and global food system; examines and analyzes local and non local components of community food systems; quantifies contributions of local food systems to their communities.	Active through Sept 2002

Table 1. Continued

Title of Research Project	Principal Investigator(s)	Relevance to the Study Questions Under Social/ Community Topic	Status/Expected Completion Date
Latino Population and Agro-Industrial Expansion: Implications for Community Development	Rochin, R. Julian Samora Research Institute, Michigan State University, East Lansing Michigan 48824	Relevant to question 1. The study measures the impacts of demographic changes at the community level with the changing nature of agriculture.	December 1998: extended
Rural Restructuring: Causes and Consequences of Globalized Agricultural and Natural Resources	Molnar, J. Department of Agricultural Economics and Rural Sociology, Auburn University, Auburn, Alabama 36849	Relevant to questions 1 and 2. The study identifies the mechanisms by which globalization processes in agricultural and natural resource systems affect farms, families and communities; assesses the range of strategies that individuals, families and communities use to respond to rural restructuring.	Active through September 2001
Impacts of Structural Change in the Dairy Industry	Smith S. Department of Resource Economics and Policy, University of Maine, Orono, Maine 04469	Relevant to question 1. The study assesses the impacts of change in farm structure on dairy industry and businesses, and on the social wellbeing and quality of life in the community.	Active through September 2001

Table 1. Continued.

Title of Research Project	Principal Investigator(s)	Relevance to the Study Questions under Social/ Community Topic	Status/Expected Completion Date
The Emerging Structure of the Global Food System: Social Consequences and Alternatives	Heffernan, W. D. Department of Sociology, University of Missouri, Columbia, Missouri 65211	Relevant to questions 1 and 3. The study aims to continue documenting the process of vertical and horizontal integration of the globalization of the food system. Other objectives include examining the characteristics and strengths of alternative organizations, with special attention on alternative food systems at the community level; social issues impacting rural and urban Missouri such as environmental, rural development, food quality, safety and quality of life concerns.	Active through June, 2000
Impacts of Structural Change in the Dairy Industry	Lyson, T. Rural Sociology, Cornell University, Ithaca, New York 14853	Relevant to question 1. Examines the relative importance and interrelationships among social, economic, technological and political environments, regional conditions and entrepreneurial strategies affecting restructuring of the dairy industry in different dairy localities. Assesses the community impacts of these changes.	Active through September 2001
Rural Restructuring: Causes and Consequences of Globalized Agricultural and Natural Resources	Lobao, L. Agricultural Education, Ohio State University, Columbus, Ohio 43210	Relevant to question 1. The research examines gender household and community adaptation strategies to social, economic and political changes in the structure of agriculture in the Midwest.	Active through September 2001

5. SUMMARY OF REVIEW TEAM, CAC AND EQB COMMENTS ON DRAFT REPORT

Future Research Needs/Research Design

We have laid out research to be undertaken primarily in Minnesota that will compare communities over time. The sampling methodology allows for the inclusion of communities that have lost (or greatly reduced) animal agriculture over time.

1. Missing Examples

We have included many more references to European examples in terms of food safety practices and animal well-being regulation.

2. Minnesota Specific Examples

We have included a great deal more data that references what is going on in Minnesota. We have brought in general data on the turkey industry, although that example is extensively discussed in the regional economy section. We recognize in the text that race is an issue in rural Minnesota.

3. Mechanisms for Conflict Resolution

The Good Neighbor Policy, promoted by the National Pork Producers, is a promising mechanism for conflict avoidance and resolution. Interviews with Bob Koehler, University of Minnesota Extension Service, who developed the materials for the NPPC, provided insight into the theoretical foundation of the program. There was no research he could point to as a basis for the programs – which is often the case for social programs in Land Grant universities, where a very small percentage of research funds address community issues. He used materials that proved a theoretical framework based on experience in industry. He did not know of any follow-up as to the differential effectiveness of the materials, but suggested that I talk to Kelly McGuire of the National Pork Producers Council. I talked to Kelly. She confirmed that they sent out many copies of the materials, but that they had not conducted any follow up as to their effectiveness. At her suggestion, I consulted with Nicole Becker of the Minnesota Pork Producers Council, which has one of the most vigorous implementations of the Good Neighbor Policy in the U.S. She feels that the program is effective, but there is no systematic evaluation to date.

I discussed mechanisms for conflict resolution – and the research base for them – with the community development extension liaisons to the North Central Regional Center for Rural Development from the 12 North Central states. While a few case studies in which Cooperative Extension was a partner are documented, there has been no systematic analysis of them.

4. Lack of Information on Social Implications of Large Facilities

To date, there have not been studies comparing different types of animal agriculture operations in communities beyond those identified in the literature review. The Kerr Foundation recently funded a study to look at the impact of integrated hog production in Guymon, Oklahoma. The research from that study is currently under peer review. There are no studies on the positives for confinement facility workers. Research is underway at the University of Missouri that will shed light on that issue.

One reason that there is little research on the social impact of larger facilities is the structure of research funding. Interestingly, much of the critical work on meatpacking has come from non-land grant universities: University of Nebraska, Omaha; University of Kansas; and University of Northern Iowa. The studies on shifts in structure of animal production tend to be done by economists, as discussed in the section on regional economics. Systematic sociological and anthropological studies to answer the key questions put forward in the scoping document require considerable resources in terms of people and dollars (although not as much as the research in the production sciences). And in Minnesota there has been a decline in the number of social scientists addressing these issues around the state, although some of the outlying experiment stations and state universities are now hiring scholars interested in these topics.

We have presented the studies that have been done on the social implications of large facilities. Scholars in social sciences tend to address issues related to change and power differentials. Thus there is a growing literature on many aspects of the sustainable agriculture movement. And there is foundation support for looking at social problems and an interest by non-economist social scientists to address issues of differential power – which in part explains the number of studies of the meat packing industry in the context of communities.

We have sent appropriate material to the regional economy section, including that related to changes in property values. The research that has been done has tended to look favorably at alternative meat production systems and negatively at concentrated meatpacking facilities.

5. Missing Topics/Research

There is a vast literature on the relation between social and economic inequities and the impact on rural communities. None look at animal production. We have listed two key studies that do an excellent job of demonstrating the impacts of inequality on community social capital and community institutions. These studies show that political involvement tends to be based on patron-client relationships between the few power holders (who usually do not run for public office) and specific family groups among the rest of the population.

There is no research on enjoyment of property, but we have suggested that it be specifically studied in future research, using the indicators mentioned.

We did not find any research on the increasing distance between people and animals. The consumer and citizen group research suggested the importance of information about how a

product is produced to facilitate proper information to consumers and to give back proper price signals to producers.

In reference to explaining the term "More Law and Less Order," that was not a term from our report – it was provided by one of the members of the CAC – and it is therefore difficult for us to explain what exactly the board member meant by it. It is a great phrase, however.

We have very carefully chosen research on other controversial industries, particularly in regard to environmental racism. There are certainly important lessons to be learned, particularly in terms of citizen mobilization.

We did not undertake a review of the considerable literature on farmers and the perception of farmers. None of that literature to date specifically relates to animal agriculture, except in the case of broiler producers. More research in this area is underway through a joint project of the Farmers' Legal Action Group with the University of North Carolina.

There is no systematic research or case studies on feedlot-related conflict in community.

We have incorporated research from economics, geography and anthropology.

6. Parallel to Meatpacking Industry

The question is how much of a parallel can be draw between meatpacking and processors. Meatpacking processors are basically the same thing. Studies on the impact of meatpacking generally relate to increasing changes in the size and composition of the labor force, as well as the presence of point pollution source in a community. Comparisons of meatpacking and processing make sense in terms of suing an organization, impacts on social capital to a new source of point pollution, and when new structures of animal agricultural growing changes the demand for labor. We have tried to clarify that in the text.

7. Missing Reports

We have dropped the reference to property values and turned it over to the externalities committee who will include our date in that study. Enjoyment of property may or may not be monitorized into property value. Thus we have omitted reference to Palmquist, Roka and Vukina (1997), which was refereed, and Edelman (1996) and Taff, Tiffany and Weisberg (1996) which are not refereed. In general, we have avoided reports that are not peer reviewed.

8. Food Systems/Consumption

Information on trends in meat production and distribution are included in other sections. We have suggested action research to better link consumer preference data to animal production practices.

9. Clarification

It is not possible to use the word "contractor" or "grower" rather than production contract when we are talking about the contract itself. It is the *content* of the contract that affects the contractor and they must be kept as separate articles.

We have discussed the use of food stamps as an indicator of poverty in our research methodology. It is a good way to compare a county to itself over time to show shifts in poverty levels. It is not a good measure of the absolute level of poverty in an area. It is especially useful as an indicator in changes in poverty levels between federal censuses. Those data are available more rapidly and more frequently than census data showing the percent of population in poverty.

We have explained in the introduction the strength and limits of case studies.

We have incorporated the references and comments of the outside reviewers to the degree possible, given the reorganization of the document and the division of labor with the regional economics and human health sections.

Suggestions that were not incorporated into the text or explained in the preceding section we address here. We did not find studies in the U.S. on hogs as "mortgage lifters," although some of the studies done in the first part of the 20th century and in developing countries show animal agriculture as a risk reduction strategy. Many of the questions from Kemp are answered in the section on the role of government. In Welch's helpful review, we did not incorporate data on size and structure of production, waste management and environmental implication, as those are dealt with in the studies on water quality and waste management.

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Land Use

B

Generic Environmental Impact Statement on Animal Agriculture:

A Summary of the Literature Related to Land Use (B)

Prepared for the Minnesota Environmental Quality Board

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EXECUTIVE SUMMARY: LITERATURE REVIEW ON LAND USE

General Comments on Results

The Literature Review for the GEIS on Animal Agriculture reviewed literature addressing:

- the sources of land use conflicts around animal agriculture,
- the land use strategies in use to address the conflicts, and
- the effectiveness of the land use strategies.

Because of the social science nature of the topic, literature reviewed included scholarly and professional journals, but also included industry and trade journals, and law review articles. The literature review report is written to describe the debate around land use issues and report on the differing views within the debate that are found in the literature.

The scholarly and professional literature identifying the sources of conflict and the strategies addressing the conflicts was adequate. Animal agriculture and land use is a very timely issue. Most of the important pieces of literature were published within the past five years, and several sources were published during the research period for the report.

Relatively few articles were found that consider the questions of how effective the various land use strategies are in addressing the conflicts around animal agriculture, or the costs and benefits of land use strategies. The report recommends future research focus on assessing the effectiveness of land use strategies on reducing identified conflicts. For example, a study of the impact of local zoning regulations on the locational decisions of feedlot owners/operators would help in assessing the effectiveness of local regulations.

Sources of Land Use Conflict

Land use conflicts surrounding animal agriculture are framed in terms of the differing value systems of people. People value land as a commodity, a natural resource, habitat, a cultural setting, and an aesthetic amenity.

Local land use decision-making is the forum used by the community to resolve conflicts such as those surrounding animal agriculture. A typical land use decision-making process includes the following steps: the issue/conflict is perceived; the issue/conflict is defined; factual/scientific information is obtained and reviewed; stakeholders provide anecdotal and perceptual data to elected officials and staff; a solution is crafted and reviewed by stakeholders; and a solution is adopted.

This report addresses how the conflict is perceived and defined, and the solutions that are crafted and adopted. Other literature reviews presented some of the factual/scientific data that is used in the process.

The sources of land use conflict identified in the literature include:

- environmental concerns (odor, air pollution, water contamination, manure handling and storage),
- human health concerns,
- nuisances (both agricultural use vs. non-farm rural uses, and small vs. large agricultural uses),
- differing rural aesthetics,
- threat to traditional rural culture,
- the use of land for agriculture vs. the use for tourism/recreation,
- fear of property value reduction, and
- fear of rural "brownfields" (contaminated sites that can not be reused for other uses without significant clean-up).

Land Use Strategies

The literature review identified four broad categories of land use strategies used to address conflicts over animal agriculture: comprehensive planning; zoning; ordinances/strategies with environmental requirements; and other ordinances/strategies.

Comprehensive planning generally defines where different land uses should be located within a community. The comprehensive plan expresses locally desired solutions for land use conflicts and sets a strong legal base for ordinance-based strategies. Townships and counties in Minnesota can use the comprehensive planning process to express how they want to address animal agriculture.

The literature reviewed paid particular attention to zoning strategies that could be used by townships and counties to address feedlots. The strategies discussed include:

- Multi-tier agricultural districts
- Separation standards
- Setbacks from roads
- Minimum site area requirements
- Limiting number of animals by area
- Definitions for non-conforming or non-complying structures that brings pre-existing operations under current land use regulations
- Requiring a Conditional Use Permit
- Special Exception review
- Performance standards or BMP's
- Clear definitions of what is regulated
- Site suitability standards/ performance standards
- Exclusive agricultural zones
- Large minimum lot sizes w/small building lot sizes
- Urban expansion zones/ urban growth boundaries
- Establishing an Ag Preserves area under the MN Ag. Land Preservation Act
- Purchase of Development Rights
- Transfer of Development Rights

Ordinances or strategies that address environmental requirements may be adopted by local governments. The literature suggests that local governments may adopt the following ordinances to address animal agriculture:

- Counties may adopt feedlot permitting standards that are more stringent than the standards required by the Minnesota Pollution Control Agency.
- Townships and counties can require that manure management plans be filed with the local government and be made available to the public.
- Manure application restrictions, including setbacks from waterways and wells can be adopted.
- Requirements for the closure of manure storage lagoons may be adopted.

Finally, the literature mentions several other types of ordinances or strategies that are used to address conflicts over feedlots. These include:

- Locally adopted right-to-farm ordinances that restate or make stronger the state statute.
- Requiring financial assurances for clean-up of manure spills.
- Equitably and consistently enforcing regulations that do exist.
- Putting moratoriums in place in order to have time to fully address conflicts.
- Landscape strategies including trees as buffers and odor filters, and creating treatment wetlands.
- Addressing general non-farm, rural development pressures to reduce conflicts.

The Effectiveness of Various Land Use Strategies

There is virtually no literature assessing the effectiveness, or cost and benefits, of various land use strategies that are used to address conflicts over animal agriculture. The few studies of the effect on property values of nearby feedlots show conflicting results. The general field of fiscal impact studies (not specific to feedlots) consistently show that new residential development is more fiscally advantageous if it is located in or adjacent to existing urban areas. The proximity of non-farm, rural residential development to feedlots gives rise to many of the conflicts described in the literature. Combining these two factors may argue for, in general, locating new residential development away from rural areas where feedlots are allowed. The question of effectiveness, however, is the most ripe for future research in the land use topic area.

CRITIQUE OF THE SCOPING DOCUMENT STUDY QUESTIONS

The three questions presented in the Scoping Document on the Generic Environmental Impact Statement on Animal Agriculture in Minnesota under the Land Use topic are clearly stated and logically build upon each other. The questions ask us to first identify the land use conflicts associated with animal agriculture, then to identify what land use strategies are used to address the conflicts, and finally to examine the effectiveness and costs and benefits of the strategies.

After examining the literature pertaining to land use and animal agriculture, the land use team offers the following three general comments about the nature of the questions posed in the Scoping Document.

1. ***Type of literature reviewed.*** The literature on land use is complex. This complexity arises in part from the varying definitions of externalities associated with animal agriculture. There is a body of technical and scientific literature concerned with technological definitions of externalities. Economic literature focuses on the pecuniary definition of externalities. Legal literature and the environmental perception literature deal with the perceptual dimensions of externalities. In addition to technical and scientific literature, there is "gray" literature that communicates findings and information in the technical and scientific literature to a variety of clientele. In the land use arena, this literature is often as important as the technical and scientific literature, as it conveys the perceptions and values of particular interest groups related to animal agriculture issues.

The largest category of work reviewed for this project was scholarly and professional journals in the fields of planning, agricultural economics, soil and water conservation, landscape ecology and perception, and conservation biology. Scientific journals were generally peer-reviewed (e.g. *Conservation Biology*). Planning journals, especially those published by the American Planning Association (e.g. *Journal of the American Planning Association* and *Planning*), tended to combine aspects of either peer- or editorial board review of empirical research with theoretical discussion, commentary and practical advice from professional planners and academics. APA's *PAS Reports*, including Jim Schwab's *Planning and Zoning for Concentrated Animal Feeding Operations*, are intended to provide planners and communities with case studies, analysis of current practice, and offer advice, ordinance language or other practical tools for dealing with common planning issues.

A handful of industry journals and trade publications (e.g. *Farm Journal, Urban Land, Feedstuffs,* etc.) were included, primarily to help frame the debate for the reader. This was also the purpose for including more clearly partisan and polemical publications. A small number of law review articles and topical case law newsletters were included (e.g. *Land Use Law and Zoning Digest, New York University Law Review*). These are standard sources used by the scholarly and legal practitioner communities.

2. ***Externalities.*** Land use regulation has historically concerned itself with issues associated with the externalities of land use. Externalities refer to the effects of land use decisions made by one landowner on the ability of abutting or approximate landowners to fully exercise their property rights. Externalities can be either positive (as when a golf course opens on property across the street from an owner thereby affording scenic views and perhaps increased property values) or they can be negative (as when an adjacent parcel becomes developed as an oil refinery). Parties to an externality can be private landowners, public landowners, as well as quasi-public institutions. The nature of the impact generated may involve land subsidence (as when an adjacent owner extracts minerals beneath the surface of an adjacent parcel causing land subsidence), degraded water quality or air quality, increased vehicular traffic and a concomitant decrease in safety, or degradation of neighborhood appearance that results in property value depreciation. The point of an externality is that one land owner knowingly or otherwise generates either a cost or a benefit that accrues and must be assumed by another land owner. In other words, the recipient's decision-making process with respect to the normal exercise of property rights is affected by the cost or benefit that is generated externally to his/her decisions.

Externalities can be defined in terms of their technological, pecuniary and perceived value. These distinctions between the various definitions of an externality are important in terms of how the land use team defined its task. Other members of the GEIS team possessing far better training and knowledge have already considered the technological definitions of externalities associated with such matters as air and water quality as they relate to animal agriculture. Similarly, economists have examined the pecuniary values of these externalities. Thus, in assessing the current conflicts of animal agriculture with other rural land owners, the land use team focused of an assessment of the perceived values of the externalities associated with animal agriculture.

3. ***Barriers to implementation.*** The idea of barriers to implementation of current and potential strategies is perhaps more germane to the issue of land use than it is to other issues. Some of these barriers are defined by institutional phenomena while others are based on cultural values.

Institutional barriers to implementation of land use strategies emerge from several dimensions of the United States Constitution: the Separation of Powers Doctrine of the Tenth Amendment, and the Takings Clause of the Fifth Amendment. In addition, constitutions of the various states enable them to create and empower entities as deemed appropriate. In Minnesota, this has resulted in creation of counties and various orders of municipalities as well as special purpose districts such as soil and water conservation districts and watershed districts. Within this institutional framework, there is potential for conflict between those powers reserved for exercise at a higher level of government (e.g. water resource appropriation and air and water effluent discharge regulation) and those passed to lower levels of government. In the instance of land use, this potential is acute because land use regulation has traditionally been reserved for exercise by the lowest possible unit of government. On the one hand, a state agency establishes performance standards for on-site operation of a particular land use which may be at odds with

the wishes of the local unit of government. In addition, there is potential for variability in implementation to exist across township, municipal or county boundaries. This has potential for creating entirely different policy strategies for dealing with exactly the same problem in identical physical settings that have varying political definitions.

Cultural traditions may also pose barriers to the ability to implement land use policies. First, the United States was founded partly on the basis of rejecting monarchical control of the landscape and preserving the free exercise of property rights by those owning such rights. England and other northern European countries have had long traditions of the sovereignty owning the entirety of a country and granting rights of property use to specific individuals. Immigrants to this nation, on the other hand, recognized early the necessity of individual property ownership to developing the country's vast resource base. Whereas a new technology might be introduced to European farmers and its adoption expected within a reasonable timeframe, such action in the United States would be antithetical to the conscientiousness of American society which is designed to protect the rights of individual property owners from the tyranny of the majority.

The United States and almost all of the states have historically delegated exercise of land use regulations to the most local unit of government. This reflects the Jeffersonian ideal that those closest to the land and its operators are most knowledgeable about local conditions and needs. But it also poses a barrier to systematic implementation of policies on a regional or state-wide basis.

REVIEW OF LITERATURE

Question 1: What are the current land use conflicts associated with animal agriculture in Minnesota including conflicts with the use of resources for recreation and tourism and land for housing and urban development?

LAND USE CONFLICTS AND ANIMAL AGRICULTURE

Land use conflicts related to animal agriculture are a microcosm of the broader social, economic, environmental and legal values influencing all decisions about the use of land. Virtually every land use conflict can be framed in terms of differing value systems, and/or the weight given to a particular value. The fact that land can be simultaneously valued as a commodity, natural resource, habitat, cultural setting and aesthetic amenity complicates the land use decision-making picture. Any land use change can affect any one of these values and result in community conflict over that use.

The real, potential and perceived "detrimental offsite impacts" of a particular land use form the basis of most conflicts related to concentrated animal feeding operations, commonly referred to as CAFOs in land use literature (Schwab 1998). Throughout this report CAFO will be used in reference to animal feedlots. CAFO was originally, and still is, used by the Environmental Protection Agency Land to refer to feedlots that fell under EPA regulation. The term is coming into use in the land use literature to refer more generally to all animal feedlots. In this report, CAFO will be used interchangeably with animal feedlot, particularly in discussing literature in which the term CAFO was used.

The land use conflicts related to detrimental offsite impacts are addressed in the planning, environmental, social science and agriculture journals, as well as in the agricultural trade journals and popular press. The land use literature on these impacts tends to fall into one or more of the categories outlined in the EQB scoping document (e.g., economic, social/cultural, environmental) and many of these issues are addressed more comprehensively in other literature review reports. While it can be argued that virtually every economic development decision or environmental quality issue has a land use connection, the literature reviewed for this section had a more narrowly focused land use/planning perspective.

Land Use Conflicts - General

Conflicts over land use are colored by competing visions of economic futures, fear of perceived loss or harm (e.g., economic, environmental, health or safety), concerns about outside interference in local and/or private decisions over the use of land, and even the personal squabbles, jealousies and political rivalries of the constituent stakeholders. Teasing out the "real" conflicts from these embedded layers of values, priorities and perceptions is probably impossible. Yet planning for the best use of a particular piece of the earth's surface requires some attempt to understand the conflict origins. Without this understanding even the most objectively developed and applied land use controls will fail. Because it is human nature to "fight with the sharpest sword", land use controls can become the weapon of choice in community conflicts only marginally related to land use.

The tools of land use planning can be crafted to effectively mitigate many of the direct impacts of feedlots on the land and on the residents of surrounding communities. Land use planning can enable a community to move toward desired economic development goals while guiding that development toward the most environmentally appropriate locations. It cannot address ethical issues related to animal rights or the economic dislocations resulting from restructuring of the livestock industry.

John Ikerd's highly polemical, *Top Ten Reasons for Rural Communities to be Concerned About Large-Scale, Corporate Hog Operations* (Ikerd 1999), underscores the dilemma. Ikerd has long observed and participated in the debate over large-scale animal agriculture. His comments reflect one point on the spectrum of opinions about animal agriculture. Only two of the reasons on his list are really amenable to land use/planning solutions - odor and manure problems - and both are subject to environmental regulation when they affect air and water quality. Ikerd acknowledges that these problems can be ameliorated by the use of mitigation technologies and appropriate siting criteria. His remaining reasons - the work is not good for people, consumers will not benefit, the future of the community will be turned over to outside interests, the conflicts generated by such facilities polarize rural communities - require policy decisions that address business organization and competitiveness, quality of work life, occupational safety and health, and the economic future of rural communities. Abdalla and Kelsey have described a process for untangling these imbedded issues using a "collaborative conflict resolution" technique. (Abdalla and Kelsey 1996) Spain has discussed the importance of recognizing divergent visions of community identity in negotiating conflicts over land use. (Spain 1993)

Rural Land Use Conflicts

Rural land use conflicts existed long before the introduction of modern animal feeding operations. Land use conflicts in rural areas have often occurred between agriculture and competing economic uses of the land. Traditional, rural natural resource-based land uses - e.g., farming, ranching, forestry, mining, fisheries - now compete with other economic activities, especially those devoted to tourism and outdoor recreational land uses. (Marcouiller 1997) Heightened concern over environmental quality issues has engendered conflicts related to agricultural impacts on surface and groundwater resources and wildlife habitat. The human health effects of many agricultural practices/land uses have also become a growing concern for many farm and non-farm rural residents. The effects of various land use changes on groundwater quality - especially in rural and agricultural areas - were reported in the MPCA's recent *Nitrate in Minnesota Ground Water* report. (Minnesota Pollution Control Agency and Ground Water Monitoring and Assessment Program 1998)

The NIMBY/LULU conflicts (not-in-my-backyard or locally unwanted land uses) of urban America also have their rural counterparts. Proposals to locate highways, hazardous waste sites, landfills, power lines, big-box retail outlets, prisons and various types of industrial enterprises have encountered local opposition even in the most economically depressed rural areas. (Horah 1993) Conflicts over feedlots have resulted in manuals that guide communities on how to avoid the unwanted effects of feedlots. The Land Stewardship Project's *When a Factory Farm Comes to Town: Protecting Your Township From Unwanted Development* is one of many such guides. (Land Stewardship Project 1997)

Some of the planning and zoning literature takes a polemical approach to the issue. Michael Barrette's *Hog-Tied by Feedlots* casts rural citizens as powerless players in the war against corporate CAFOs. Barrette quotes Kendall Thu, "One of the beneficial things that happens when people fight this is that they discover that it is not about odor, it's not about pigs, or even about farming. It is about a whole constellation of issues that determine how we live our lives." (Barrette 1996)

Other researchers have taken a highly theoretical approach to analyzing land use conflicts. Thurow and Thompson used a game theory model to explain obstacles to negotiating community conflicts related to siting livestock facilities. The lack of common ethical norms amongst the various stakeholders removes the basis of communication and undermines the cooperative behavior necessary to reach compromises over siting. (Thurow and Thompson 1998)

Martin and Zering describe how the industrial concentration of livestock production has altered the public's perception of environmental risk. The larger scale of production heightens the potential for greater environmental damage, while smaller-scale operations posing smaller risks over a wider area are often not perceived to be as detrimental. The fact that large facilities are simply more visible to the public and to regulators may actually reduce environmental risks. Larger operations may be more motivated to reduce their own liability risks, and may be better

able to make the capital investments in mitigation technologies. (Martin and Zering 1997)

Abdalla and Shaffer use interest group theory to argue that the battles over animal agriculture can best be understood in terms of political interest groups allying themselves with the agency or level of government most likely to pursue their agendas. Unorganized interest groups - primarily nearby residents - tend to prefer local regulatory authority because it is perceived to be more knowledgeable about local situations and more sympathetic to their interests. Organized interest groups - including producers, other agricultural and agribusiness groups, and statewide environmental organizations - tend to prefer state-level regulatory authority. Producers may feel they have greater influence over state legislators than local planners. Agribusiness groups may desire the uniformity and predictability of regulatory impacts/costs afforded by statewide approaches. Environmental groups may have less faith in the technical and political capacity of local officials to implement their goals. (Abdalla and Shaffer 1997)

A more pragmatic approach to analyzing and resolving land use conflicts associated with animal agriculture has been adopted by other writers. Neil Hamilton, Professor of Law and Director of Drake University's Agricultural Law Center, has produced a series of articles, handbooks and white papers designed to aid livestock and other agricultural producers in navigating the sea of land use and environmental regulations and in minimizing land use conflicts. In his 1992 *Livestock Producer's Guide to: Nuisance, Land Use Control, and Environmental Law* he advises producers to make conscientious efforts to work with neighbors (including educating them about the livestock production business), to employ the latest mitigation technologies and design strategies to minimize odors and potential water quality problems, and to implement the full range of "sound agricultural practices" to avoid future problems. He also presents a thoroughgoing analysis, with representative cases, of the application of nuisance, right-to-farm, zoning and environmental protection law to agricultural land use conflicts. (Hamilton 1992) (Hamilton 1993)

Two newer sources designed for practical implementation by local governments and citizen/planners comprehensively address the range of issues and conflicts surrounding land use and feedlot siting - Duncan and Associates' *Planning and Zoning for Animal Agriculture in Minnesota* and James Schwab's *Planing and Zoning for Concentrated Animal Feeding Operations.* (Duncan 1996) (Schwab 1998)

Schwab discusses land use conflicts arising from improper manure handling, surface and groundwater contamination, odors and air quality. He addresses the potential impact of environmental degradation on recreational land uses and tourism; the economic burden on county and/or township residents of cleaning up rural brownfields resulting from improperly managed/closed manure lagoons, increased road maintenance costs. Schwab also addresses: rural economic development resource allocation conflicts, e.g., does encouraging one type of land use discourage more "attractive" economic activities/land uses; non-farm rural residences encroaching on agricultural land and the associated increase in nuisance complaints; the lack of adequate local controls and planning or enforcement staff to draft and monitor effective plans

and controls; and conflicts over the state and federal role in land use issues - e.g., environmental and health regulations. (Schwab 1998)

Urban Planning-Rural Land: Control Over Land Use Decision-Making

The imposition of urban land use controls and values on rural landowners has been the focus of several researchers. Wadley and Falk (Wadley and Falk 1993) have argued that rural notions of self-sufficiency, independence and utilitarian views of the land are at odds with the environmental and nostalgia-based attitudes of rural newcomers and urban planning elites who increasingly impose their values on the countryside (by virtue of their growing numbers and political clout). "Farm landowners believe they are losing control over land use decisions. Rural landowners reject the rationale that land regulation rescues rural land from the consequences of harmful rural-oriented uses. Rather, [they] believe the regulations are an attempt to keep rural areas pure and unspoiled for urban purposes." These suspicions are especially aggravated when regulations appear to stray from the public health and environmental quality impacts of certain agricultural land use practices, into the realm of aesthetics or toward an "urban-oriented agenda designed to shape rural land use activity to fit an urban vision of the countryside."

Several authors have called for planners and local communities to develop new models of rural planning and zoning, based not on the old urban planning framework, but designed specifically to meet the needs of rural areas. Over twenty years ago, Lefaver published an article in *Urban Land* which called for a more flexible approach to rural planning - moving away from the "unresponsive tools" of traditional zoning and density restrictions. (Lefaver 1978)

Most of the literature, however, calls for more rather than less planning - or at least taking a look at more creative strategies. (Russell 1996a; Russell 1996b) (Daniels and Lapping 1996) Rural planning guidebooks routinely encourage community residents to undertake a comprehensive community planning process to establish common goals and work out potential conflicts proactively. (Daniels and others 1995) (Duncan 1996)

Non-Farm Neighbors and Rural Newcomers

Over the last twenty years, rural areas within commuting distance of urban centers have experienced significant population growth. The conflicts generated by urban encroachment into agricultural land bear a close resemblance to those encountered by feedlots. The farmland protection literature has documented the tensions that exist over land use between farmers and non-farm newcomers to the urban-rural fringe. (Nelson 1992) (Coughlin 1991) (Thompson 1997) (Daniels1996, 1997, 1999) (National Association of Counties Research Foundation 1980)

Non-farmers are attracted to the countryside by a perception of a cleaner, aesthetically more pleasing environment than in a city or suburb. They may also be drawn by cheaper land and the potential to build a large house. Often, non-farm newcomers are able to commute to jobs in suburbs and even cities. In this sense, they are trying to have the best of both worlds: a house in the country and a high-paying job elsewhere.

It is common for newcomers to move to the countryside before they understand what life in the country and nearby agriculture are all about. For example, Larimer County, Colorado and Spokane County, Washington have both published versions of The Code of the West that warn non-farmers who are thinking about moving to the countryside about what they can expect. (A slightly edited version of Larimer County's Code of the West is re-printed in Daniels (1999)). Newcomers often arrive to find that there are a host of "spillovers" from nearby farm and ranch operations. These spillovers may include: noise, dust, odors, and slow moving farm machinery on the roads. Farmers and ranchers may experience trash in their fields, vandalism, and harassment of livestock by children and dogs. Moreover, non-farm neighbors may file nuisance suits or pressure local governments to enact nuisance ordinances to limit certain farming practices.

Researchers have shown that most ex-urbanites have no conception of the realities of modern farming. Expectations of pastoral tranquility, pristine environments and scenic rural landscapes can be shattered by the industrial scale and production methods of many agricultural operations. Heavy machinery, extended hours, bright lights, dust and flies, aerial and ground spraying of herbicides and pesticides, truck and equipment noise, and unpleasant odors are facts of life on most conventional farms. (Daniels, 1997, 1999) (Thompson 1997)

Efforts of newcomers to preserve their vision of "rural quality of life", and their propensity to value the scenic qualities of the land more than its income producing potential, come into conflict with the land use preferences and practices of long-time rural residents. (Spain 1993)

Nuisance and the Right-to-Farm

An outgrowth of the concern over farmland loss to urbanization and the rising number of complaints by non-farm neighbors against farm operators was a wave of state- enacted "right-to-farm" laws in the 1980s. These laws were designed to protect farmers engaged in normal agricultural activities. Several manuals and reports have been published to assist producers in dealing with potential conflicts with non-farm neighbors (e.g., *A Livestock Producer's Legal Guide to: Nuisance, Land Use Control, and Environmental Law).* (Hamilton 1992) Some have questioned the legal basis of these laws, asserting that they have radically restructured common law property rights.(Reinert 1998)

The Minnesota law on nuisance (Minnesota Statutes, Section 561.19) finds that an agricultural operation is not considered a private or public nuisance if the operation has been operating for two or more years and was not a nuisance at its start of operation, when the operation expanded the number of livestock by at least twenty-five percent, or when there was a distinct change in the operation, such as from dairy to hog production. However, the farm operation may be considered a nuisance if conditions or injury result from practices that are not normal farming practices or are in violation of state, federal, or local laws, rules, permits, and ordinances.

Lisansky has shown that the rationale for most of these laws - urban expansion into agricultural lands - may have been based on faulty assumptions. Size and type of farm and the community characteristics of the neighboring areas are more predictive of nuisance complaints and concerns than the actual population density or rate of population growth. Larger operations, livestock producers and farms located near areas that can be characterized as "suburban" are more vulnerable to nuisance complaints. (Lisansky and others 1988)

In September of 1998, the Iowa Supreme Court ruled the Iowa Right-to-Farm Law unconstitutional. In February of 1999, the United States Supreme Court refused to hear the Iowa case on appeal. As a result, it is likely that there will be challenges to the constitutionality of right-to-farm laws in other states.

Property Values

One of the concerns expressed by feedlot neighbors is the fear of reduced property values. The research on feedlot impacts on nearby landowners' property values is limited and contradictory. Taff's 1996 study, funded by the Minnesota Department of Agriculture, is based on 1993-4 home sales price data for Renville and Redwood Counties. Taff unexpectedly found a "positive proximity effect" - primarily for newer, higher priced homes located away from small towns and nearer feedlots.(Taff and others 1996) The one-mile increment proximity categories used in the study make these results difficult to evaluate in light of the much smaller required separation distances between feedlots and neighboring residences commonly used in many Minnesota

zoning ordinances (e.g., 500-2640 ft., depending on the size/type of operation).

The three other studies of feedlot impacts on residential property sales prices do not support Taff's conclusions. Palmquist's research of rural residential property sales in nine North Carolina counties and Abeles-Allison and Connor's Michigan study found a negative impact on home values. Abeles-Allison, however, only measured the impacts on properties in the vicinity of "problem" feedlots. Palmquist reported a 4.75% reduction in value for homes located within 1/2 mile of a hog operation. (Palmquist and others 1997) (Prof. Pat Norris of the University of Michigan is working on revised version of the 1990 Abeles study)(Abeles-Allison and Conner 1990). Rikoon et al. (1999) studied four northern Missouri counties and found that properties within two miles of a CAFO experienced a loss in value.

See also the discussion these studies in the External Benefits and Costs Literature Review, pages F-23 to F-25. The conclusion of the External Benefits and Costs report is that too few studies have been completed to draw conclusions about the impact of feedlots on property values.

Property Rights

Balancing the constitutionally protected property rights of individual landowners with the legitimate public interest in protecting the health, safety and welfare of the community has always been the challenge of land use regulation. The growth of federal and state involvement in the land use arena - primarily through environmental regulation - has led to increasing conflicts over the appropriate level and extent of government involvement in land use decision-making.

The feeling that federal and state regulations have usurped local and/or individual decision-making powers over land use has led to the growth of strong property rights and "wise use" movements in many parts of the country. More than half of the states have some type of property-rights legislation. (Jacobs 1998) Some commentators believe property rights issues have been oversold to agriculture - potentially resulting in a backlash movement, e.g., the recent fate of Iowa's "right-to-farm" statute being ruled unconstitutional. (Hamilton 1995) Others acknowledge that the movements have succeeded in shifting the debate - making governments and regulators at all levels more sensitive to property rights issues, and "bringing these issues into public consideration in a more explicit way." (Jacobs 1998)

Environmental Quality

Schwab (1998) describes three main environmental issues associated with CAFOs: odors, air pollution, and water pollution. Odors vary according to the type of livestock, the number of livestock, and the degree of concentration. Generally, hog odors create the most complaints, followed by the smell of chickens, cattle, and turkeys. The distance that odors travel will depend on the location of CAFOs, prevailing wind direction, and temperature and humidity (the greater

the temperature and humidity the more powerful the smell). Air pollution from CAFOs is a separate issue from odors. Air pollution can negatively affect human health and even livestock on neighboring farms. Water pollution can degrade drinking water supplies. Water pollution from CAFOs can occur in a number of ways. CAFOs also consume large amounts of water.

Another environmental land use issue concerns the eventual closure of CAFOs and in particular manure lagoons. There is a concern that some operators may simply abandon the farms, creating "rural brownfields" with concentrated pollution and an expensive clean-up challenge. Although concern about brownfields was raised in recent planning literature about CAFOs (Schwab 1998), no literature documenting feedlots as a cause of rural brownfields was found.

Concerns over the real and potential air and water quality impacts of intensive livestock facilities are in many ways a subset of the more general concern for the environmental consequences of all types of agricultural land use practices. (Caldwell 1998) Land use conflicts over environmental quality can also occur because different groups of rural residents (newcomers v. long-time residents or farmers v. non-farmers) do not assign similar values to environmental protection (or may dispute the causes of degradation). Hurley's study of rural residents' level of concern over water quality from the potential siting of a large livestock facility near their homes showed that occupation, age and source of drinking water influenced the level of concern over about potential nitrate contamination of drinking water. While all respondents expressed concerns about drinking water contamination, farmers, retirees, those over age 60 and municipal water users expressed a higher level of concern. Half of the survey group believed environmental issues were a high local policy concern, but farmers and male respondents generally gave these issues a lower priority. Hurley comments, "This is an interesting paradox since farmers indicated a greater concern over the potential for water contamination from large-scale confinement operations." He postulates that many of these farmers were small hog producers "masking concerns for economic survival in terms of water quality." (Hurley and others 1999)

Outsiders - tourists, hunters, anglers, and other outdoor recreationists - may hold entirely different views. The growing use of regions formerly devoted exclusively to agricultural production as places for pursuing leisure activities - recreational trails, wildlife watching, sport fishing, driving through the country - brings the environmental and "landscape consumption" values of visitors into conflict with local residents. (Marcouiller 1997) (Spain 1993; Clawson 1974)

Land Use and the Rural Landscape

Landscapes are a complex amalgam of landforms, topography, vegetation, water and climate, man-made structures, human culture and perception. The power of landscapes to impart meaning and values to human beings has spawned a literature devoted to empirically assessing the role of landscape perception and visual preference, visual resource management and the relationship between landscape aesthetics and landscape ecology. (Zube 1976; Kaplan) (Schauman 1979)

Although the mandate of the National Environmental Policy Act of 1969 to give "appropriate consideration ... to presently unquantified environmental amenities and values" has gained substantial legitimacy over the past thirty years, it has not come about without serious conflict. (Pitt and Zube 1987)

The loss of rural cultural landscapes, traditional rural scenery (e.g., old farmsteads, hedgerows, pastured animals) and other visual impacts on the rural landscape have been addressed in David Copps' *Views From the Road: A Community Guide for Assessing Rural Historic Landscapes.* (Copps 1995) The aesthetic of rural preservationists may not always coincide with that of people who make their living from the land. The conflict of aesthetic definitions between those who value "working rural landscapes" and those who cherish the "beautiful countryside" is also a function of familiarity with changing technology and production methods, e.g., bright lighting in and around linear rows of corrugated sheet metal buildings might look oddly industrial and out of place to an outsider, but it is simply a functional expression of the production needs and 24-hour operating schedule of the facility. (Riley 1985) Added to the conflicts between those who perceive landscapes for their use value and those who value landscapes primarily as amenities is another dimension - ecological health - which is often unrecognized and unseen. (Nassauer 1989; Nassauer 1992)

The relationship of the visual quality of the landscape to recreation and tourism development, and the potential conflict between traditional land uses - including agriculture - and outdoor recreation and tourism has been studied most extensively in the context of rural forested landscapes. Clawson's study of land use incompatibility problems between recreational and natural resource based uses focused on conflict management and dispute resolution strategies. (Clawson 1974) Marcouieller's recommendations for integrating tourism planning more broadly into rural development strategies also addressed the issue of land use conflicts:

> Increased use of rural areas for tourism coupled with an increased awareness of visual aesthetics and concerns about biodiversity have led to visitor skepticism toward traditional economic uses of natural resources in rural areas and to compatibility issues of traditional land uses with ... tourism. Tourism-based development of rural regions has limited compatibility with the manner in which these lands are managed for commodity production. (Marcouiller 1997)

The rural landscape has been transformed over the past 50 years by changing agricultural technologies and land uses that have dramatically altered the function and appearance of the land. (Riley 1985) (Hart 1998) The shift away from mixed-use/small grain and pastured animal production toward intensive, specialized row crop, livestock or poultry production has resulted in a "cleaner" more stripped-down agricultural landscape. The loss of hedgerows, woodlots, shelterbelts, pasture and hayland, and wetlands of the pre-1950 farming era have corresponded with significant declines in pheasant and other grassland bird populations. (Friesen and others 1999) (Warner 1994) The decline of these features in the modern rural landscape has also reduced its visual diversity. These losses may also impact the perceived desirability of a region as a destination for visitors, especially birders, pheasant hunters and those looking to take in the countryside scenery.

But it not just for outsiders that rural landscape quality matters. "Farmers are more likely to participate in [conservation] programs that enhance the look of their farms." Rural residents have their own community- based standards of beauty. "People have widely shared values about what makes landscapes beautiful. People who have similar experiences - farmers or others who live in a particular region - have similar ideas of landscape beauty. We can say a lot about what makes rural landscapes beautiful if we include people who are familiar with an area in the discussion. Rural Midwesterners' perceptions of landscape aesthetic quality may be ... bound to larger concepts of stewardship." (Nassauer 1989)

Question 2: What zoning and land use planning strategies exist, to what extent are they in place in Minnesota and how effective are the land use planning strategies?

- ***a. addressing the identified land use conflicts;***
- ***b. promoting citizen participation;***
- ***c. identifying and promoting the best uses of the land;***
- ***d. addressing development pressures in agricultural areas;***
- ***e. reducing negative environmental, economic, health and social impacts of animal agriculture; and***
- ***f. balancing property rights?***

GENERAL ISSUES OF AUTHORITY FOR LAND USE REGULATION OF ANIMAL AGRICULTURE IN MINNESOTA

The issues involved in the land use regulation of siting and operation of concentrated animal feeding operations are many, complex, and interrelated. In general, there are two main issues: 1) regulating the operation of new and existing CAFOs; and 2) regulating the location and design of new CAFOs. Health and environmental regulations generally emerge from the state or federal government. Local land use planning and zoning are generally directed at regulating the location and design of new CAFOs. The Role of Government report addresses the question of the implications of regulating animal agriculture at different levels of government. This report briefly addresses the authority of local land use control, what current land use strategies are in use and their effectiveness.

Legal issues first and foremost concern the legal authority that local governments, including townships and counties, have to regulate CAFOs. The legal basis of local authority for planning and zoning are discussed at length in the Role of Government report, however, a brief discussion is warranted here. The Tenth Amendment to the United States Constitution allows state governments the power to exercise their police power to protect public health, safety, and welfare. Local governments are the creation of the state government. The state government, through state zoning and planning enabling legislation, decides what powers of land use control to delegate to the local governments. Unlike other states, such as Iowa, **Minnesota does allow local governments to use zoning to regulate agriculture in general, and specifically CAFOs** (Minnesota Statutes, Section 394.25 (counties) and Section 462 (townships)). Also, local governments may enact environmental and health regulations that prevent private property owners from creating public nuisances.

Another issue is the effect of zoning and other regulations on private property rights. The Fifth Amendment to the Constitution states that a government cannot take private property without paying "just compensation." A regulation is not a physical taking of property in the manner of a condemnation by use of eminent domain powers. Zoning and other regulations, however, can become a taking if they are unreasonable and result in taking all of the economic use of a

property.

Obviously, a tension occurs between the Fifth Amendment and the Tenth Amendments. State and federal courts continue to vary in their interpretations of these two amendments in land use cases. Nonetheless, the regulation of CAFOs appears to have strong support as being in the interest of the public health and safety.

Finally, the Fourteenth Amendment to the Constitution requires due process and equal protection under the law. This means that governments must respond in a timely and procedurally correct manner for land use permits and decisions, and that all citizens must be treated the same. Governments cannot make arbitrary and capricious decisions. For example, this means that a government could not delay indefinitely a decision on whether to issue a building permit for a CAFO. In Minnesota, however, a local government (in this case a Township) may impose a moratorium on the permitting of new CAFOs while drafting new zoning and environmental regulations (Duncanson v. Board of Supervisors (Minn. App. 1996)).

As discussed in *Planning and Zoning for Animal Agriculture in Minnesota: A Handbook for Local Government,* Duncan and Associates (1996a) highlight the potential interaction between state and local regulations. They raise the question of what authority local governments can exercise. They ask, for example, can state regulations "pre-empt" local regulations? This is the case in Iowa where CAFOs are regulated by the state; local governments cannot use zoning powers to regulate CAFOs. In *Goodell v. Humboldt County* (IA Sup. Ct., March 1998) the Iowa Supreme Court ruled that the 1996 ordinances adopted by Humboldt County to control large operations were not valid. These ordinances did not apply zoning regulations to operations, rather the ordinances required large operations to obtain county construction permits. The construction permit process included a process for public hearing, manure management plans, financial assurances for clean-up, and restrictions on application of manure around drainage wells. The Iowa Supreme Court held that the ordinances violated the state's scheme of uniform regulations. In a strong dissent, however, two justices said the Court's ruling called into question the applicability of county "home rule" as guaranteed in Iowa's constitution.

Duncan and Associates strike a note of caution about whether local zoning in Minnesota could be pre-empted by state regulations. Duncan and Associates cite the Minnesota right-to-farm law and the Agricultural Land Preservation Act as examples of where the state has made incursions into local regulation. The Minnesota right-to-farm law grants immunity from most public and private nuisance actions for operations that have been in operation for two or more years and follow "generally accepted agricultural practices." The Agricultural Land Preservation Act allows land enrolled in Agricultural Preserves some special, though not absolute, protections against annexation, condemnation, and public uses.

In his review of local government authority across the country, Schwab (Schwab 1999) states that local governments in Minnesota have the authority to use planning and zoning to regulate CAFOs.

The Minnesota Court of Appeals recently supported the position that local governments have the authority to adopt land use restrictions on feedlots. In the Minnesota case of *Canadian Connection v. New Prairie Township* (581 N.W. 2d 391), the Court of Appeals held that the New Prairie Township ordinance imposing setback requirements on feedlots was valid. The Court specifically held that the ordinance did not conflict with MPCA permitting authority and was not pre-empted by the act of the MPCA issuing a permit to the feedlot. Even though MPCA issued a permit, the Township ordinance prevented the feedlot from being built because it did not meet setback standards.

Duncan and Associates (1998) note that the Minnesota Pollution Control Agency has the authority to regulate the environmental impacts (air and water pollution and smells) of feedlots. It is an open question whether local governments can address the environmental impacts of CAFOs in their zoning ordinances.

LAND USE STRATEGIES FOR ADDRESSING CONFLICTS OVER ANIMAL AGRICULTURE

With the notable exceptions of Schwab and Duncan (Schwab 1998; Duncan 1996a,b), most of the land use literature does not directly address the issue of regulating feedlots. The literature explains the planning and zoning process as applied to rural areas in general and agricultural land protection specifically. Agricultural land protection is pursued for many reasons, including the reduction in conflicts between neighbors over odor, noise, and dust. These conflicts also arise with concentrated animal feeding operations. Therefore, some of the strategies suggested to address agricultural land protection can also be applied to the regulation of CAFOs.

Addressing Land Use Conflicts

Duncan and Associates argue that "in most Minnesota counties, existing controls to protect agricultural land are inadequate." In 1996, "only 20 counties in the state [had] comprehensive plans that [were] ten years old or less. Although a vast majority of Minnesota counties (61 out of 80) [had] adopted county-wide zoning controls, few use measures such as exclusive agricultural zoning districts or residential density standards [were used] to protect agricultural land" (Duncan and Associates, 1996b, p. II-2). A survey of county use of agricultural zoning conducted in 1997-98 for the Minnesota Department of Agriculture found 45 counties with density requirements of at least twenty acres per residential unit. (Resource Management Consultants, Inc., et al., 1999)

Comprehensive Planning

Local comprehensive plans form the legal and policy basis for local land use ordinances in Minnesota. Through statute, the State of Minnesota has given authority for comprehensive

planning to counties (Minn. Stat. Section 394.21 *et seq.*) and cities and townships (Minn. Stat. Section 462.351 *et seq.*). The development of comprehensive plans should involve citizens in defining community needs, issues, goals and solutions. Comprehensive planning can specifically direct the creation of ordinances to implement the goals of the plan.

Agricultural land uses, and animal agriculture specifically, can be addressed in a comprehensive plan. Comprehensive plans should reflect community values, culture and history as well as the community's vision for the future. As noted by Schwab (1998) a well-developed comprehensive plan that outlines what land uses the community wants and where they should be located prepares communities to respond to CAFO siting requests.

Zoning Strategies

In his handbook for local government officials dealing with animal agriculture in Minnesota, Duncan and Associates suggests that counties and townships create multi-tier agricultural districts: a limited agricultural district in which crop farming is the dominant enterprise, and a general agricultural district in which CAFOs would be allowed and indeed encouraged to locate. The general agricultural districts would be further removed from non-farm residential, or urban areas. This concept is similar to what is currently done in zoning industrial uses: a light manufacturing zone for firms that generate few spillovers onto nearby properties, and a heavy manufacturing zone for firms that produce noise, dust, and odors that could travel some distance. The creation of two agricultural zones was done in 1998 in Elkhart County, Indiana. The county's A-5 zone allows farm operations with 3,000 or more head of livestock, and the A-1 zone allows farm operations with fewer than 3,000 head of livestock.

A sample ordinance incorporating the multi-tier agricultural zones, conditional use requirements, and land use standards for CAFO's is included in the handbook. The land use standards include:

- setback requirements from roadways,
- separation standards from other land uses,
- minimum site area requirements, and
- definitions for nonconforming uses and noncomplying structures that when met would bring pre-existing operations under current land use regulations.

In the companion handbook explaining the Minnesota Agricultural Land Preservation Act, Duncan discusses the establishment of agricultural preserves, exclusive agricultural zones, and urban expansion zones as possible solutions for land use conflicts over animal agriculture.

In *Planning and Zoning for Concentrated Animal Feeding Operations* (Schwab 1998), Schwab presents a thorough explanation of the legal and environmental issues involved in the regulation of CAFOs. The land use conflicts center on the potential creation of public and private nuisances by CAFOs and the fear on the part of CAFO operators that public hearings will turn into free-for-all attempts to ban CAFOs.

The report also discusses the local government zoning ordinances that have been used to regulate CAFOs. Schwab distinguishes between zoning for future land uses and local environmental and public health regulations that can be applied to existing land uses. Zoning affects future land uses, once land uses are properly permitted they retain a right to exist and are subject to zoning only when there is a change or expansion of the existing use that is not permitted. Schwab pointedly notes that zoning cannot be used to shut down legally permitted existing uses, including CAFOs.

Zoning strategies listed by Schwab that can be used for addressing CAFOs include:

- agricultural districts that allow CAFOs to be separated from non-farm land uses;
- separation standards that establish minimum distances between incompatible uses such as CAFOs and residences;
- conditional use standards requiring a higher than normal level of review for compliance with the standards;
- performance standards or best management practices for the siting and operation of CAFOs that address potential impacts on natural resource and surrounding land uses; and
- moratoriums on the siting of CAFOs to allow local governments time to develop plans and regulations.

Resource Management Consultants (1999) examined several Minnesota counties which use some form of agricultural districts. This report evaluates the effectiveness of state agricultural land preservation programs and does not directly consider animal operations. Nicollet County implemented an agricultural zoning ordinance in 1985 and allows one dwelling unit per 40 acres. The County reports that there have been no major rezonings of agricultural land to residential or other non-agricultural uses in the 85% of the county land area zoned for agriculture.

In Stearns County, twenty of the thirty-seven townships in the county have agricultural zoning ordinances with varying density requirements. There is currently a moratorium in the county to slow down the increase of rural non-farm development and consider more comprehensive agricultural zoning. The report also noted that Grant County is not considering any planning and zoning.

The Resource Management Consultants report also describes the results of a survey of counties regarding the status of zoning for general agricultural land protection in Minnesota. Almost 13.5 million acres of agricultural land in 45 counties is currently under some type of agricultural zoning. Four counties the allowable density in agricultural zones is one residential unit per 20 and 40 acres. Forty-one counties allow one unit per 40 acres or more. More than 56% of the agricultural land in Minnesota (as identified by the 1992 USDA Census of Agriculture) is zoned under the limits stated above. Seventeen counties have implemented agricultural zoning ordinances since 1990. The report describes Minnesota as "at the forefront of states in the nation adopting agricultural zoning."

Patricia Norris (July 1999) discusses an integrated planning and zoning approach that may be

used by township governments in Michigan. She states that "planning and zoning for animal agriculture cannot be simplified as an issue of planning and zoning for agriculture in general", rather specific regulations should be directed at CAFOs. Townships in Michigan, similar to townships and other local governments in Minnesota, do have the authority to zone and regulate agricultural land uses. Norris suggests regulations that: clearly define what animal agricultural uses are regulated; set limits on specific concerns such as size and proximity limits for odor; and consider site suitability standards. Norris suggests using a special permitting process for animal operations.

Mo and Abdalla (1998) incorporated the presence of local zoning ordinances in their study of the effect of regulation on the expansion of the swine industry. Their study included examining the variable of whether or not states allowed local governments to zone for agricultural land uses or whether the state exempted agriculture from local zoning. This was one of seventeen variables incorporated in a linear model to estimate the relationship between the variables and swine industry expansion. They did not examine the effects of specific zoning strategies. The results indicated that states with laws that provide an exemption had a greater growth or slower decline in the swine industry than states without an exemption.

While not addressing CAFOs directly, Daniels (Daniels, 1999) and the American Farmland Trust (1999) are the most recent general discussions of the land use conflicts associated with urban growth in rural areas. Growth in America today is occurring in the "rural-urban fringe" on land outside of established cities and towns. This pattern of residential development on one-, two-, five-, and ten-acre lots is bringing many newcomers into conflict with farming operations, especially those farms that have livestock.

Even with incentives and regulations to keep agricultural land open for agricultural use some development will continue to occur in the countryside. The important issues are where the development happens and at what scale and density. Rural residential zones, such as in Oregon, can be used to accommodate residential development away from commercial farm operations and thus reduce potential conflicts.

Daniels notes that an effective technique to separate urban uses and rural areas is the urban growth boundary or village growth boundary. This technique, pioneered in Oregon, has been adopted in communities in California, Colorado, Florida, Kentucky, North Carolina, Pennsylvania, Virginia, Washington, and in the Twin Cities metropolitan region in Minnesota. A growth boundary comes about through an agreement between local governments (a city and a county, or between a city and neighboring townships), or in the case of the Twin Cities region, between local governments and the regional planning agency (the Metropolitan Council). A growth boundary contains enough buildable land to support development over the next 20 years. Urban-type services, such as public sewer, water, and schools are placed within the growth boundary to encourage a more compact form of development and minimize sprawl into areas with farm uses.

Purchase of development right (PDR) and transfer of development rights programs (TDR) and cluster subdivisions are also used throughout the country for the protection of agricultural land in general. (Allman 1997; American Farmland Trust 1997; Daniels 1997; Schnidman 1990) The application of these techniques should be considered in the development of programs to separate animal agriculture from incompatible uses.

In a PDR program, a local government purchases the right to develop land from the landowner for the purpose of limiting the future use of the property to agricultural and open space uses. A permanent conservation easement is placed on the land to prevent future development. TDR programs allow development rights to be transferred from farmland to urban areas. Local governments adopt an ordinance that defines a sending area where agricultural resources are to be protected, and a receiving area where development is encouraged. Landowners in the sending area can chose to sell development rights to developers. Developers use the development rights to develop a parcel in the receiving area at higher densities than typically allowed. A permanent conservation easement is placed on the land that sold development rights to prevent future development.

The Minnesota Legislature, in 1997, amended the land use authority of counties and municipalities to specifically include the authority to establish PDR and TDR programs. (1997 Minn. Laws Chapter 216, sections 135 and 138) Washington County has explored the possibility of establishing a PDR program, and Chisago County is in the preliminary stages of considering the development of a TDR program. (Resource Management Consultants, Inc. 1999)

The Minnesota Legislature, in 1997, also amended the land use authority of counties to require notice of a permit to construct four or more residential units on land zoned for agriculture (or agricultural land in counties without zoning) to owners of all agricultural land within 5000 feet of the proposed development. (Resource Management Consultants, Inc. 1999)

The recent evaluation of Minnesota Agricultural Land Preservation Programs (Resource Management Consultants, Inc. 1999) recommends that the Minnesota Department of Agriculture analyze and summarize the effectiveness of TDR and PDR programs as agricultural land protection tools. Depending on the findings, the Department may choose to assist counties in the development of programs.

Cluster development (Arendt 1994: Yaro 1989: Washington County 1997) is also promoted as an tool for the protection of farmland from non-farm uses. Cluster development ordinances for agricultural protection typically require new developments in agricultural areas to cluster housing on small lots away from agricultural operations, permanently preserve at least half of the open space in the development. Cluster developments are encouraged in Washington County under their density-based land use requirements. Clusters are, however, essentially suburban housing developments placed in the countryside. The location of these non-farm developments near CAFO's could merely increase conflicts.

Other Local Regulatory Strategies

Duncan and Associates (1996a) also suggests the adoption of a local right-to-farm ordinance as an additional tool to decrease conflicts between CAFOs and other land uses. Local right-to-farm ordinances can complement the state right-to-farm law. Duncan suggests incorporating an "early notice" provision that may prevent people from "coming to the nuisance." A sample local right-to-farm ordinance is included in the handbook.

Enforcement of Local Regulations

Local land use regulations may be enforced at several points in time: when a permit (building, certificate of occupancy, zoning change, variance, conditional use permit, etc.) is applied for; when parcels of land are sold or subdivided; and when violations occur. If a land use regulation for a feedlot is violated, the local enforcement officer (often the zoning officer or feedlots officer) can enforce the regulation within the process and penalties outlined in the ordinance. Local enforcement officers become aware of violations through citizen complaints and visual inspections. A consistent criticism, however, of all types of local land use regulations is that regulations are not consistently enforced. The general farmland protection literature urges local governments to apply ordinances consistently to prevent challenges to the ordinance and to achieve the goals of the ordinance. Enforcement of an ordinance is often more important than the adoption of the ordinance. (American Farmland Trust 1997) (Daniels 1995) (Lefavor 1978)

Minnesota Agricultural Land Preservation Program

Duncan and Associates (1996b) discusses Minnesota Statutes, Chapter 40A of 1984, better known as The Minnesota Agricultural Land Preservation Program. This statute establishes a program to offer property tax incentives to farmers who put their land into an "agricultural preserve." In return, farmers place a restrictive covenant on the land, limiting the use to agriculture. Farmers may petition to remove the covenant in a process that takes at least eight years, or the county may remove land from an agricultural preserve. Enrolled farmland also receives:

- exemptions from local ordinances that restrict normal farming practices, "unless the ordinance has a direct relationship to public health and safety" (Chapter 40A.12);
- limits on annexation;
- greater protection from eminent domain actions;
- ban on public facility siting in preserve areas; and
- exemptions from special assessments.

Chapter 40A defines "Agricultural Use" as the production of livestock, dairy animals, poultry or poultry products, fur-bearing animals as well as crops. Duncan and Associates states that the question of whether a CAFO could locate in an agricultural preserve and receive exemptions from local ordinances that restrict normal farming practices remains unanswered. If a CAFO were challenged in court, the court would have to rule whether a CAFO and its mode of

operation constituted a "normal agricultural practice."

As of 1996, only 3 non-metro counties were using the Agricultural Preserves Program with about 152,000 acres enrolled (Duncan and Associates, 1996b, p. III-2). An Agricultural Preserves Program must be integrated "with comprehensive county and municipal plans" (Chapter 9 40A). Agricultural land must be identified, along with growth trends and housing needs, and sewer and water facilities. Land classified for long-term agriculture becomes eligible for the Agricultural Preserves Program.

Once the agricultural land preservation plan has been developed (with public input), local land use controls must contain the following provisions to implement the plan:

- the creation of exclusive agricultural zones that allow for conditional, compatible uses that do not conflict with long-term agricultural use;
- designation of urban expansion zones where limited growth and development may occur;
- residential density and minimum lot sizes in exclusive agricultural use zones and urban expansion zones; and
- standards and procedures for county decisions on rezoning, subdivision, and parcel division.

Duncan and Associates discusses the treatment of a CAFO as a conditional use, a special exception, or an outright permitted use in an agricultural preserve. Conditional uses and special exceptions must meet specific articulated standards involving siting and design considerations in order to be permitted. Conditional use permits are generally imposed on land uses that have the potential to cause impacts over a large area. A special exception is a decision of the zoning board and involves a land use that impacts only immediate neighbors to the use. In general, the purpose of a special exception is not to keep out a certain use, but to make sure that it will operate responsibly and with a minimum of spillover effects onto neighboring properties. An outright permitted use requires no more than a building permit, as long as zoning setback, height, and bulk coverage requirements are met.

Resources Management Consultants (1999) in their evaluation of Minnesota Agricultural Preservation Programs, report that participation in the statewide program is limited to only three counties (Waseca, Winona, and Wright) that participated in a pilot program early in the program's history. Approximately 156,000 acres have been enrolled in the three counties out of a total potential acreage of 979,000 acres. This report recommends the following changes in the Program to increase its effectiveness:

- increase the property tax credit;
- increase the enrollment period from eight to 10 years;
- strengthen the prohibition on annexations of any land enrolled;
- provide for differential assessments as well as property tax credits;
- instill confidence in long-term funding of the Program;
- increase education and outreach efforts;
- require density-based zoning with maximum lot size provisions and clustering of non-farm residential units;
- require zoning densities of one unit per 40 acres; and

- produce model agricultural zoning ordinances.

Minnesota Feedlot Permit Program

In 1998, Minnesota SF 3353 established a program for the authorization and transfer of feedlot permits, although MPCA has permitted feedlots since 1971. Under the new program, counties may adopt standards for animal feedlots that are more stringent than those of the Minnesota Pollution Control Agency. After January 1, 2001, a county that has not accepted delegation of the feedlot permit program must hold a public meeting before the MPCA can issue a feedlot permit for a facility with 300 or more animal units. Any state or local government agency that conducts an inventory or survey of feedlots must publicize notice of the inventory in a newspaper of general circulation in the relevant area. Local governments conducting an inventory must hold at least one public meeting. Until June 30, 2000 neither the MPCA nor a county board may issue a permit for the construction of an open-air clay, earthen, or flexible membrane liner swine lagoon.

Another provision of the law required counties and towns that adopt ordinances related to animal feedlots to supply copies to the Commissioner of Agriculture by August 1, 1998. This collection of Minnesota ordinances is the most comprehensive found and is discussed below.

Promoting Citizen Participation

While literature addressing citizen participation in the context of developing land use policy and regulation for CAFOs is unavailable, the general planning literature does give some guidance. *The Small Town Planning Handbook* (Daniels, 1995) details how to involve the public in the creation or updating of a local comprehensive plan. Elements of effective public participation include:

- comprehensively identifying stakeholders;
- reducing barriers to participation (travel time, child care, time of day, time of year, fear of speaking in public);
- providing a variety of access points to the process (written materials, small meetings, large meetings, media coverage of the process, individual access to elected officials, staff and consultants); and
- incorporating iterative meetings where the results of prior meetings are explicitly used in subsequent meetings.

The book also explains how to create or update a local zoning ordinance, subdivision regulations, and capital improvements plan. The book places a great deal of emphasis on public involvement because the authors' belief that if the public helps create the plan, the public will support the plan and the ordinances that put the plan into action. The book also tells how to hold a fair public hearing.

James Duncan and Associates' (1996a) Minnesota handbook emphasizes a comprehensive planning approach which includes extensive citizen involvement in "visioning" and participating in the drafting of a comprehensive plan.

Community-based comprehensive planning is promoted in Minnesota under the Community-based Planning Act adopted in 1997. This legislation established eleven statewide goals for local comprehensive planning, and provided technical support for communities completing local comprehensive plans that emphasized local citizen involvement. According to Minnesota Planning (1999) sixteen of Minnesota's 87 counties are participating in community-based planning, along with numerous cities, townships and other local governmental units. State funding grants for community-based planning projects by local governments will end in June 2000. During the last session, the Minnesota Legislature passed legislation that will cause the Act to end, or sunset, in June 2001.

Addressing Development Pressures in Agricultural Areas

Daniels and Bowers (1997) in *Holding Our Ground: Protecting America's Farms and Farmland*, discusses the development pressures that farmers face in terms of the economics of farming, the conflicts created by non-farm neighbors, property taxes, and the "Impermanence Syndrome" in which farmers reduce investment in their operations as they perceive the inevitability of development. The book presents a thorough explanation of the techniques used to protect and preserve farmland, including: comprehensive planning, zoning, property tax programs, right-to-farm laws, urban growth boundaries, purchase and transfer of development rights. The book also talks about how to put together a strategic package of protection and preservation techniques.

Reducing Negative Environmental, Economic, Health, and Social Impacts of Animal Agriculture

Health and environmental standards are not the traditional methods used in land use planning, however, some environmental regulations are adopted as land use controls. (Schwab 1998) Schwab observes that environmental regulations differ from zoning controls in that they apply to both existing and future land uses.

Schwab lists several environmental regulations that have, or could, be used to reduce the negative impacts of animal agriculture. Lagoon closure requirements are one strategy that could be used in dealing with CAFOs. Closure requirements were one subject of the Humboldt County, Iowa, ordinances discussed above that were overturned. Financial performance guarantees are another strategy for protecting against the abandonment of CAFOs. Manure application setback requirements also fall into the environmental regulation category. A final strategy suggested by Schwab is requiring public access to Comprehensive Nutrient Management Plans as suggested by the US EPA. This would allow interested individuals to view and assess the proposed location and timing of manure applications.

In a July 6, 1999, *Farm Journal Today* article, Bernick, describes the two-year moratorium on new hog facilities that was imposed in North Carolina from mid-1997-mid 1999. The North Carolina legislature is considering a two-year extension of the moratorium. North Carolina

Governor Jim Hunt has ordered state inspectors to assess the environmental risks of each manure lagoon in the state by September 1, 2000. Hunt is willing to spend state dollars to close abandoned lagoons, but also wants the livestock industry to help pick up the cost, which could be as high as $400 million. Hunt is also proposing a 10-year phase out of all lagoons.

Balancing Property Rights

The concept of property rights can change over time, as can the responsibilities that attach to owning land, such as the responsibility not to pollute the air and water. Jacobs, in *Who Owns America? Social Conflict Over Property Rights* (1998) has collected papers about property rights and responsibilities. The idea that landowners can do what they want with their property is contrary to the laws against creating public and private nuisances. But the use of private property has been central to America's economic system. The tension between private property rights and society's interests is a continuing struggle.

Schwab (1999) makes the argument that regulations aimed at controlling the environmental effects of CAFOs are on strong legal footing. Schwab contends that these regulations are clearly intended to protect public health from air and water pollution. Moreover, the regulations do not take away all possible economic uses of a property, and hence are not a "taking" under the 5th Amendment.

Balancing property rights is not directly addressed in local zoning ordinances. In *The Livestock Management Act & Other Zoning Issues - Impact on Non-Farm Residential Use in an Agricultural District,* Carmichael (1997), discusses the balancing act that counties must perform in attempting to regulate CAFOs through zoning one the one hand and upholding private property rights on the other. Carmichael points out that inconsistency in zoning regulations and zoning enforcement is a major problem among counties in Illinois. Daniels and Bowers (1997) explain what a local government can and cannot in zoning agricultural land. The chapter includes several citations of court cases about the legality of agricultural zoning, and how the extent of regulations in agricultural zones varies from state to state.

Use of Land Use Strategies for Regulating Animal Agriculture in Minnesota

See also the Role of Government Report section on County Feedlot Ordinances.

As stated, local governments in Minnesota have the authority to enact zoning ordinances for the regulation of animal feedlots (Duncan 1996b). Local government interest in feedlot ordinances was prompted at the beginning of this decade by the emergence of new facilities considered "large" by traditional standards. Fears of odors and to a lesser degree fear of water quality risks, and concerns about ownership and community change caused the calls for controls.

Many Minnesota counties and townships have adopted feedlot ordinances in the past few years. Some counties and townships do not have feedlot ordinances per se, but use the regular zoning requirements such as setback from right of way, as requirements for issuing permits for livestock

facilities. Feedlot ordinances usually address a much broader array of concerns.

Some of the provisions commonly found in Minnesota feedlot ordinances are:

- **Setback distances** from rural residences, towns, parks, etc. (some are set such as shoreland)
- **Conditional use procedures and requirements** (including conditions dictating when a conditional use is required such as feedlot size)
- **Hearing process** (notification procedures, timelines, etc.beyond state requirements).
- **Fee Schedules**
- **Lagoons and Earthen Basins** (requirements beyond MPCA standards)
- **Required manure storage capacity**
- **Acres required for responsible manure utilization**
- **Land ownership requirements**
- **Feedlot licensing and inspection**
- **Allowable number of animal units per site or section**

Issues sometimes addressed in conditional use permits requirements are:

- **Road damage occurring from feedlots or feedlot construction**
- **Manure incorporation requirements**
- **Accessibility for inspection**
- **Responsibility for cleanup if abandoned**

Elected officials and appointed planning commissioners who develop and set policy for zoning/feedlot ordinances are often plagued by the confusion of environmental and land use issues with agricultural policy and social issues. In general, zoning deals with land use, feedlot permits address environmental concerns (but the distinction is somewhat blurred), and neither are particularly designed to deal with agricultural policy and social issues. However, agricultural policy and social issues are often the motivation for calls for stricter environmental and land use controls.

Land use ordinances are ever- changing: it is difficult to summarize current provisions – there are very often calls to address new concerns as new situations arise, usually prompted by an individual application. Some individual county ordinances have been opened for revisions 3 or 4 times since their original enactment

Summary of Animal Related Ordinances in Minnesota

The 1998 Legislature passed Minnesota Laws Chapter 401 Sec. 57 requiring all counties and townships to submit copies of their animal-related ordinances to the Minnesota Department of Agriculture (MDA). MDA received a variety of animal related regulations taken from adopted and draft feedlot ordinances as well as zoning ordinances, land use plans, development codes,

shoreland ordinances, and interim ordinances. A total of 79 of Minnesota's 87 counties responded to the reporting requirement. Of the 79 counties, 64 submitted animal-related ordinances, 15 reported no ordinances and 1 reported an animal-related ordinance but did not submit it. Eight counties did not respond. The ordinances submitted included 29 zoning ordinances, 20 feedlot ordinances, 3 development codes, 3 interim ordinances, 3 shoreland ordinances, and 5 draft feedlot/zoning ordinances.

Twenty-seven townships also submitted animal-related ordinances. The township ordinances have not been summarized. MDA does not have current plans to summarize the township ordinances. This is a choice based only on lack of funding for staff to undertake the summary.

MDA has prepared a draft report summarizing the county ordinances. MDA states that the challenges posed by logistics, incomplete submissions, and the complexity of regulations limit this report from 100% accuracy and inclusivity. However, MDA staff have made a strong effort to make this study an enlightening summary of county animal-related ordinances as of March 22, 1999. The data presented gives a good representation of the situation as it existed in early 1999.

From the submitted animal-related ordinances MDA staff developed three tables profiling county animal-related ordinances that are presented in their report, "Summary of Animal-Related Ordinances". The first table profiles feedlot regulations on requirements for separations distances (also called setbacks in many cases), conditional use permits, maximum animal units, and minimum acreage. The second table profiles setback requirements for land application of manure, and the final table profiles manure incorporation and certificate of compliance requirements.

The MDA did not make an assessment as to the effectiveness or appropriateness of the provisions in the ordinances. Also, there is no assertion that the most commonly occurring provisions and specific values are in some way more "right" than others.

Following is a summary of some of the findings in the report.

Setbacks and Separation Distances

All of the animal-related ordinances include setback requirements and separation distances standards. Separations distances are often referred to as "setbacks", which is the preferred terminology in the majority of submitted ordinances. Separation distances and setbacks are however different in purpose. "Setbacks" are primarily useful as a means of protecting adjacent rights-of way and lots from encroachment by buildings and structures. "Separation distances and standards" are land use control strategies that are based on the notion that spatial segregation is the best method of ensuring that different land uses do not have an adverse effect on one another.

The MDA survey found that counties have primarily used two different methods for separation standards and setbacks. The two methods are "simple" and "sliding scale". The most common approach reported was the use of simple standards (28 counties). The definition of "simple

standards" is that the number of animal units is not considered when determining separations distances and setbacks. Table 1 shows the number of counties with "simple standard" separation distances for feedlot facilities from specific land uses and the distances reported.

Table 1: Range of "Simple Standard" Separation distances

Separation Distances From:	Lowest Distance Reported	Highest Distance Reported	Median	Mode
Neighboring Residence	500'	2,640'	1,160'	1,000'
Park	1,000'	5,280'	2640'	2640'
Church	1,000'	2,640'	2640'	2640'
10 or More Residential Dwellings	2,000'	5,280'	2640'	5,280'
Residential District or Development	500'	10,560'	2640'	2640'
Municipal Boundaries	2,640'	10,560'	5,280'	2640'

2640'= ½ mile
5280'= 1 mile

The highest distance reported compared to the lowest distance reported for the separation of feedlots from various land uses ranges from approximately 2-1/2 times greater (church and 10 or More Residential Dwellings) to 21 times greater (Residential District or Development). Since simple standards do not consider animal units or technologies employed, the distances reported suggest considerably different perceptions about the necessary distance to protect other land uses from feedlot impacts and create widely different conditions for operators of similar feedlots based only on county of location.

Nineteen counties reported a sliding scale system for setting separation distances and setbacks. The standards varied widely between counties and are difficult to summarize. For distance from "neighbors" the median was 1000' for 1-300 animal units, 1320' for 301-1000 animal units, 1320' for 1001-2000 animal units, and 2640' for 2001-5000 animal units.

The report provides information on the specific factors used by individual counties using a sliding scale system. Four counties reported using type of manure storage as a factor in determining separation standards and setbacks. Two counties allowed a reduction in setback distances if an odor reduction technology is employed and approved by the county planning commission. One county reported using prevailing wind direction as a factor in conjunction with number of animal units.

Since odor concerns are often cited as the major reason for setting separation distances, and since factors including local conditions, species, animal housing type, manure storage technology, and number of animal units can affect odor risk, it appears that the Odor Rating System under study

by the University of Minnesota with funding and support from MDA, or other techniques to quantify odor risk and intensity, could assist counties to improve effectiveness and consistency in setting appropriate separation distances. Currently widely varying standards are being used in Minnesota counties to deal with the issues connected to separation distance.

Size Limitations

Thirteen counties limited the maximum size of feedlots. Those limits varied from 1000 hogs (equivalent to 400 animal units) in one case, and 1,500 animal units (equivalent to 3,750 finishing hogs) in 3 others, and up to 5,000 animal units (equivalent to 12,500 finishing hogs). The other counties had no size limit per se but it could be surmised that that applications for very large feedlots would be severely scrutinized through means such as conditional use in many or all of those counties.

Thresholds For Conditional Use Permits

Conditional Use Permits are required in some ordinances under certain specified conditions. They imply that the use somehow requires additional deliberation beyond that applied by the standards of the ordinance. A planning commission may require conditions above those in the ordinance standards if the conditional use is granted. A public hearing process is involved in a conditional use procedure.

An argument for the liberal use of conditional use permits (requiring them at a low threshold-in the case of feedlots usually a size based on number of animal units) is that each application can be studied on its individual merits and that the public can have input in those permitting situations. Negatives seen for low conditional use thresholds are that bias is more likely to enter the process (as opposed to enforcing impassionately arrived at standards) and that politics can become a factor in granting permits. Conditional use procedures also can be costly, both to the applicant in preparation and time, and to the county in staff time and planning commission and hearing costs. Counties may attempt to offset some of the cost with conditional use fees paid by the applicant.

MDA staff summarizing conditional use standards for the *Summary of Animal-Related Ordinances* found it very difficult to profile the thresholds for conditional use permits. The thresholds are primarily based on animal units and often include additional considerations such as distance to adjacent land use and zoning districts, type of manure storage facility and land application of manure, requirement of an environmental assessment worksheet or a NPDES permit. The thresholds vary widely from county to county. For example, in reviewing individual county reports one can find an instance of three adjoining counties in southwest Minnesota, one with no conditional use procedures required, one with a 300 animal unit threshold, and the third with a 1000 animal unit threshold. This is representative of the differing philosophies on employing conditional use procedures versus establishing and enforcing standards.

Minimum Acreage Requirements

Some counties have adopted minimum acreage requirements to site animal feedlot operations. The advantages of requiring a minimum number of acres for an operation include: the opportunity for the owner to place the livestock facility further from the property line, and; additional value for the site if it should ever be defaulted to the county. The additional value could be used to cover potential clean-up costs if the property went tax forfeit. Opponents of this concept see it as discriminatory compared to requirements for other uses, and an artificial barrier to feedlot siting.

Eleven counties in the survey required some level of minimum number of acres required to site a feedlot. Among the highest requirements were one county requiring 40 acres, one requiring 40 acres for over 2000 animal units, and one requiring 20 acres up to 300 animal units, 75 acres for 301 to 2000 animal units, and 115 acres for 2001 to 5000 animal units.

Manure Application Setbacks

Table 2 below shows the range of manure application setbacks, in addition to the most commonly found setback requirements.

Table 2: Range of Manure Applications Setbacks

Manure Application Method	Streams/ Rivers	Lakes	Wetlands	Tile Inlets	Wells Public/ Private	Residential Dwellings/ (10+neighbors)	Drainage Ditch	Roads (right of way)
Surface Applied	50-750' typically 300'	50-750' typically 300'	50-500' typically 300'	10-300' typically 100'	50-1000/50-1000' typically 1000/200'	50'-1 mile/100-500' typically 200/200'	16.5-500' typically 300'	25-100' typically 25'
Injected	50-300' typically 100'	50-300' typically 100'	25-300' typically 100'	10-300' typically 10'	100-1000/50-300' typically 1000/200'	50'-1 mile/100-1000' typically 500/300'	16.5-100' typically 100'	10-200' typically 10'
Incorporated	10-300' typically 100'	50-300' typically 100'	50-300' typically 100'	10-300' typically 10'	100-1000/50-300' typically 1000/200'	50'-1 mile/100-500' typically 100/100'	16.5-300' typically 100'	10'
Irrigated	50-500' typically 300'	50-500' typically 300'	50-500' typically 300'	10-300' typically 10'	100-1000/200-500' typically 1000/200'	50'-1 mile/50-500' typically 100/100'	50-300' typically 300'	25-300' typically 300'

Manure Application Setbacks Within Shoreland Areas

The State of Minnesota requires local governments to adopt and implement shoreland protection ordinances that meet or exceed state thresholds for land use in shoreland areas. The threshold requirements include limitations on the application of manure within the floodplain areas of lakes and rivers. These thresholds apply in all local jurisdictions unless exceeded by local ordinance area. Several of the county feedlot ordinances submitted to MDA specifically restate these limitations, while others exceed the limits.

Reflections on the Survey Findings

It is easy to conclude from the survey findings that there is a wide variety in both the provisions included in local ordinances, and the specifics of those provisions. There have been attempts to encourage more consistency in the ordinances between counties in Minnesota. This activity has included the development of "Model Ordinances" that were adopted in 1996 by the Association of Minnesota Counties. In some instances these model ordinances have served as the foundation or beginning document in a development process for a county adopting an ordinance for the first time. However, no regions of the state have adopted multi-county ordinances, and it is unlikely that any two county ordinances are exactly alike.

The value of consistency has been debated. Some producer groups feel that wide variations between counties create an uneven playing field for producers. Policy makers defending variety contend that differing county situations (feedlot density, topography, population density, local culture and history, presence of lakes and streams) dictate differing ordinance provisions. Others feel that feedlot ordinances, like traffic laws could be determined statewide, with the standards and provisions for a feedlot being determined by site specific conditions as spelled out in a state or regional ordinance.

The situation around state and local feedlot regulation is dynamic and controversial. County ordinances are variable and subject to frequent changes. Meanwhile more townships are considering adoption of ordinances. The same turmoil exists at the national level as states struggle to find effective and fair ways to deal with a changing livestock industry.

Separation Standards - How Far Away is Far Enough

The traditional basis of planning and zoning is the separation of conflicting land uses. However, very few places in the United States employ "exclusive farm zones" in which only agriculture and agriculturally-related activities are allowed. Far more common are "non-exclusive agricultural zones." The non-exclusive zones allow non-farm residences, usually by right or in a few cases, by special exception. The question becomes: how many houses can a farmer farm around and avoid complaints or threats of nuisance suits? The number of non-farm houses is usually based on a minimum lot size. For example, a 40-acre minimum lot size would mean that a landowner would have to own or purchase 40 acres in order to erect a house. Large minimum lot sizes tend to discourage non-farm buyers because of the price and the fact that most non-farm buyers don't want 40 acres for a building lot. Small minimum lot sizes, such at 2-acres or 5-acres,

typically lead to an influx of non-farm residents. This is when the trouble usually begins between non-farmers and feedlot operators. (Coughlin 1981; Daniels 1997; Schindman 1990; Steiner 1984).

The location of an animal feeding facility in relation to non-farm neighbors is important for potential complaints and nuisance suits. The farther an operation is from non-farm neighbors, the the lower the likelihood of complaints and nuisance suits. The National Pork Producers Council has recommended a modified version of an Austrian federal guideline designed to be incorporated into local land use development plans. The state of Iowa requires distances of 750-2500 ft. between residences and various CAFO structures. (Lorimor 1995)

The Model Feedlot Ordinance adopted in 1996 by the Association of Minnesota Counties' District VIII Feedlot Task Force recommends a 1/4 mile setback from a single neighboring residence and a 1/2 mile setback from 10 or more residences or a municipality. (Association of Minnesota Counties 1996) As discussed above, local governments in Minnesota have required setbacks and separation distances ranging from 500 to 2640 ft. The application of empirical research regarding the most effective separation, set-back and buffer distances for mitigating odors from animal feeding operations would aid in the development of more uniform standards.

A design-based approach to separating many types of agricultural land uses from non-farm uses has been to cluster non-farm rural residential lots on a smaller area of land away from neighboring farms. The protected open space buffers the residential cluster from farm impacts (and visa versa) and can serve as an aesthetic amenity or wildlife area. (Arendt 1994; Yaro, et.al 1989).

Landscape Based Strategies

Implementing land use policies and/or practices which simultaneously address aesthetic and ecological values and still meet the mitigation needs/concerns of intensive livestock production presents real challenges. Nassauer's explorations of the link between the appearance of agricultural landscapes and their ecological health in the corn and soybean country of Minnesota and Iowa may be relevant ((Nassauer 1979; Nassauer 1986; Nassauer 1989; Nassauer 1992) Using the Conservation Reserve Program (CRP) as a possible vehicle for incorporating aesthetic objectives into agricultural conservation policy, she has attempted to develop a set of visuals cues - based on culturally recognized aesthetic norms and indicators of good stewardship - that would serve to portray the landscape care intended by the farmer. Many of these cues/signs are directly translatable form row crop to animal agriculture - others would have to modified.

Nassauer discusses several rural landscape qualities - scenic quality, neatness and stewardship - that were ranked highly by her Minnesota research participants:

> Scenic quality will be most apparent to tourists and it relates most directly to economic development opportunites. Scenic quality often is apparent in landscapes that have a mix

> of land suitable for cultivation and land that farmers might describe as "not meant to be farmed," too steep, or too wet for farming. Where farming has respected limits imposed by natural features... the landscape is often scenic. (Nassauer 1989)

While this type of scenic beauty is also recognized by farmers, they have a different set of aesthetic standards for their own land:

> Neatness is the aesthetic theme traditionally associated with good farming. The fact that farmers have control over and responsibility for the neatness of their land helps to explain why neatness is attractive. By keeping farmsteads and fields neat, farmers also express a concern for their neighbors and the appearance of the neighborhood. Unlike scenic quality, neatness shows what the farmer has been doing; it reflects on the farmer.
>
> Farmsteads and rural residences described as neat are well-maintained (buildings recently painted, new or highly functional agricultural buildings); grass is mown; trees, shrubs, flowers, and often fences and lawn ornaments are included on the site. Equipment is not left outside; any buildings not being used have been taken down. Interview participants suggested that a neat farmstead indicated that the farmland itself was well cared for. (Nassauer 1989)

Stewardship is the third landscape theme. It is not necessarily visible and is often open to misinterpretation:

> Stewardship is not always noticeable. Many conservation practices demonstrate no visible control by the farmer. They may even be taken for signs of neglect. No-till farming, wetland restoration, and perennial cover on CRP land are examples. (Nassauer 1989)

Using socially recognized signs of stewardship to portray ecological health and human purpose in the rural landscape involves "labeling ecological function" with conventional signs of human intention, "setting expected characteristics of landscape beauty and care side by side with characteristics of ecological health." (Nassauer 1992)

Designing CRP land (or other rural landscapes) to better communicate their ecological benefits and make it clearer that such areas are not being neglected might involve selective mowing (neatness), introducing flowering plant species into roadside or fencerow vegetation (scenic beauty), or using fences and signage to provide information about the purpose of the landscape. (Nassauer 1989)

A demonstration project is currently underway in Hamilton County, IA to determine the "aesthetic, odor control and economic benefits of tree landscaping around hog barns." Iowa Select Farms has been working in partnership with Trees Forever, a nonprofit environmental organization, to study how plants affect odor control. "A major goal of the project is to determine which species of trees do the best job of filtering particulate matter, thereby reducing odors." Other goals of the project are to improve energy savings from the use of tree windbreaks, attract

wildlife by providing food and cover in the form planted trees, shrubs, native grasses and wildflowers (which is also intended to reduce mowing) and created wetlands, and generally improve the appearance of the facility and grounds. (Bernick 1999)

The use of treatment wetlands to improve water quality, e.g., from urban stormwater and wastewater, is becoming increasing popular. (Kaldec and Knight 1996) They are often more cost effective then conventional treatment methods, and offer ancillary benefits such as wildlife habitat and recreational open space. Wetland vegetation and wildlife provide aesthetic enjoyment and can become magnets for birdwatchers. Constructed wetlands are also finding their way into the agricultural environment to treat animal wastewater.

The Tennessee Valley Authority, in cooperation with the Soil Conservation Service (now NRCS) and Auburn University built one of the first such systems in 1988. The system at Auburn's Sand Mountain Agricultural Experiment Station was constructed to handle effluent from a secondary lagoon treating waste from approximately 500 hogs. (Hammer 1993) The number, size and type of animal facilities served by such systems has now expanded significantly. (Constructed Wetlands for Animal Waste Management 1996) (Schwab 1999; Henderson 1998)

Question 3: What are the costs and benefits of these different land use strategies?

The literature quantifying the costs and benefits of different land use strategies as applied to animal agriculture is nearly nonexistent. As noted earlier in this report, and researched in the External Benefits and Costs report, the research on the cost and benefits of feedlot impacts on nearby landowners' property values is limited and contradictory. (Taff and others 1996) (Palmquist and others 1997) (Abeles-Allison and Conner 1990) (Rikoon 1999).

There is, however, substantial literature investigating "smart growth", the cost of public services and the fiscal impact of various types of urban development. These studies, including the most recent study by the Minnesota Department of Agriculture on cost of services, show that "new residential development is more fiscally advantageous when it occurs within or adjacent to established urbanized areas." (Duncan Associates 1999) Low-density residential development is more expensive than high-density development. The cost of services studies and fiscal impact studies are in virtual consensus. The conclusion that increasing density decreases societal, public, or private costs is held by nearly every type of organization that has studied the cost issue. (American Farmland Trust 1986, 1992, 1994; Burchell 1992: Center for Energy and Environment 1999: Dahlgren Shardlowe Uban 1996; Fodor 1997; Gray 1989; Minnesota Extension Service 1996; Minnesota Planning 1997a,b; Sherburne County 1995; Young 1995)

The agricultural land protection policy debate is informed by cost of service and fiscal impact studies. These studies are often used to support the development of growth boundaries and agricultural preservation programs. It can not necessarily be assumed, however, that these results transfer directly into the debate over siting and operating animal agricultural operations.

The 1999 Duncan report for the Minnesota Department of Agriculture reports on case studies in five Minnesota Counties where they applied a fiscal impact model developed for the project. Key findings of the study include:

- Urbanization accounted for only a portion of Minnesota's decline in agricultural acreage. Other factors included: lower market prices, soil degradation, and greater production efficiencies.
- Where agriculture is a large part of the tax base, it usually produces more in taxes than it requires in services.
- New residential development will likely generate a financial shortfall for all five county governments over the next two decades.
- New residential development will generally come closer to supporting itself in cities than in townships when the combined impact on county and municipal budgets is considered.

These key findings reflect the findings of the other Minnesota specific cost of service studies; that agricultural land demands less in service costs than it contributes in taxes. (American Farmland Trust 1992, 1994; Gray 1989; Sherburne County 1995)

GAPS IN THE LITERATURE AND RECOMMENDATIONS FOR ADDITIONAL RESEARCH

As highlighted in the report, the two areas with virtually no literature responding to the scoping questions are:

- the effectiveness of suggested land use strategies over time, and
- the costs and benefits of land use strategies used to address animal agriculture conflicts.

The results of research on effectiveness and costs and benefits would be helpful to local policy-makers and community residents in making choices between strategies. These two research areas are related in that effectiveness could be researched in cost/benefit terms. Research on effectiveness could also measure indicators of effectiveness such as:

- nuisance complaints,
- non-farm residences within proximity of feedlots,
- conditional use requests and whether or not conditions are complied with,
- request to view comprehensive nutrient management plans,
- abandoned operations and clean-up procedures, and
- other responses of operators.

Additional effectiveness related research questions include:

- What is the cost to producers of complying with the regulations?
- Are land use regulations influencing the size and location of CAFOs?
- Are the regulations creating quantifiable benefits, such as improvement in air and water quality, and reduction in complaints from non-farm neighbors?
- Are regulations aimed at closure and clean-up of manure storage lagoons working satisfactorily or are "rural brownfields" being created? Who is paying to clean up abandoned manure lagoons?
- Do local governments have adequately trained staff and equipment to enforce zoning and environmental regulations concerning the siting and operation of CAFOs?
- What are reasonable setbacks, screenings with trees and vegetation, and best management practices?
- What are the risks to local governments in operators suing over land use regulations?
- What are some examples of citizen participation in the creation of local government comprehensive plans and zoning ordinances that involve the regulation of CAFOs?
- Are different zoning and environmental regulations more effective for different animal species?
- Does the use of moratoria result in better policy development?

These many questions for future research suggest that it will be many more years before the impacts of attempts to regulate CAFOs will be fully known.

LIST OF RESEARCHERS CONDUCTING ON-GOING RESEARCH

Key Researchers	On-going Research	Expected Completion Date
Prof. Ronald Fleming Dept. of Agricultural Economics, University of Kentucky	Manure Application Setbacks	February, 2000 Land Economics
Prof. Jim Pease Dept. of Agricultural Economics, Virginia Tech University	Impact on dairy production of implementing best management practices to improve water quality	December 1999
Prof. Pat Norris Agricultural Extension Economics Service, Michigan State University	Appropriate setbacks for concentrated agricultural feeding operations	September 1999
Mr. Lee Christensen USDA - Economic Research Service, Washington, D.C.	Constructed wetlands as an alternative swine waste treatment option	September 1999
Prof. H.L. Goodwin Dept. of Agricultural Economics, University of Arkansas	A planning tool for local governments in planning and zoning for CAFO's. Model uses Geographic Information System spatial analysis with multiple criteria to identify suitable locations for CAFO's.	Spring 2000

Note: The Indiana Department of Environmental Management is currently working on regulations for large hog farms. IDEM 100 N. Senate, P.O. Box 6015, Indianapolis, IN 46206-6015. Phone # (317) 233-6645.

SUMMARY OF COMMENTS ON THE DRAFT REPORT

The draft Land Use report was commented on by CAC members and two outside reviewers. The general topic areas of the comments and the manner in which the comments were addressed in the final report are summarized below.

1. *What was the decision rule used to determine if materials were reviewed and included or excluded?* The decision rule was made much more explicit in the Critique of the Study Question section of the report. In addition, since there was much concern expressed about the use of opinion pieces, we tried throughout the report to explicitly explain the nature of documents reviewed.

2. *Include more discussion about the effects of various land use policy choices.* This comment was consistent in all reviewers. As stated in the report, there are very few studies of the effects of land use policy choices. The literature found has been included in the report. Suggestions on further research in this area, and possible methodologies, has been included in the section on future research needs.

3. *Review the draft for tone and bias.* The draft was revised to exclude bias from the authors.

4. *Do the landscape conflicts and solutions receive too much emphasis?* The rural landscape perception and ecology literature is a significant part of land use planning literature and practice. The authors feel that the relative weight this topic received is not inordinate.

5. *CAC comments on clarifications.* All but one of the clarification questions were addressed in the final report. The only clarification that is unresolved is how many of the respondents to the county survey on agricultural zoning conducted by Gray (1999) that are listed as "no ag. zoning/no response" were actually no response. After reviewing the report and talking to the author, the question is still unanswered.

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Role of Government

C

Generic Environmental Impact Statement on Animal Agriculture:

A Summary of the Literature Related to the Role of Government (C)

Prepared for the Minnesota Environmental Quality Board

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EXECUTIVE SUMMARY

The Role of Government Literature Review for the GEIS on Animal Agriculture undertook the substantial task of documenting and understanding the roles of all levels of government in regulating animal agriculture. This report combines traditional literature review with a cataloging of laws, regulations and rules that address animal agriculture. The literature review aspect generally addresses the questions of how effective the laws, regulations and rules have been in achieving their stated goals.

In response to the question, "What are the government policies and programs directed at animal agriculture and human health as it is impacted by animal agriculture in Minnesota. . . ?", this report provides brief summaries of many state and federal statutes and regulations. These summaries provide explanations of key provisions of the various laws and legal citations. The summaries cover relevant laws administered or enforced by Minnesota's Pollution Control Agency, Department of Agriculture, and Department of Natural Resources; the United States Environmental Protection Agency; and the United States Department of Agriculture. The summaries also cover authorities of townships and counties to regulate animal agriculture.

The literature review revealed that government involvement in agriculture, including animal agriculture, is generally aimed at achieving one or more of the following goals:

- regulating farm prices and income;
- increasing production;
- maintaining a safe food supply;
- conserving and protecting the environment;
- correcting market failures;
- preserving family farming; and
- addressing other social concerns.

To achieve the goals listed above, several types of government intervention are highlighted in the literature. Domestic farm programs have historically provided billions of dollars annually to farmers and landowners. Typically these benefits have gone to crop farmers, and in particular to larger farms.

Considerable government attention is designed to conserve or regulate natural agricultural resources and protect the environment. USDA programs, including those affecting animal agriculture, target conservation and environmental concerns. The recently announced EPA/USDA Clean Water Action Plan, for example, involves a shift in policy to emphasize control of nonpoint sources of pollution -- particularly animal waste. There is a general sense noted in the literature that legal liability for environmental violations in agriculture is on the rise. Nuisance law is the main legal remedy in such cases. Nuisance and other legal actions, however, have been limited somewhat by various state Right to Farm laws. These laws may prove increasingly ineffective and may in some cases be abandoned. As a point of comparison, some European nations have enacted a strict set of environmental controls along with lucrative

incentive programs for livestock producers. Researchers have also begun to ask the question of how much environmental regulation of animal agriculture actually costs. Some economists are beginning to consider, for example, the appropriate level of subsidy to use to encourage farmers to adopt conservation practices.

Though typically not acknowledged as a farm policy, federal, local, and state taxation policies and US monetary policy have a direct effect on the shape of animal agriculture. A significant body of evidence, however, suggests that tax policy affects the operation and organization of U.S. agriculture in significant ways. Overall, tax policy seems to have encouraged farm expansion and the reduction in the number of farms.

Other areas of government activity that are addressed in the literature and are important to animal agriculture include: trade policy; marketing and demand expansion programs; food safety regulation; programs designed to provide credit to farmers; disaster assistance and crop insurance; regulation of conduct with animals; regulation of sales; and contractual relationships of corporate farming.

The report reviews sources of funds received by the University of Minnesota for animal agriculture research, education and training, and how the funds were expended for recent years. There are no studies that address how the allocation of funds impact animal agriculture in Minnesota. On the national level, however, information on rates of return on investment in animal research show that research investment is a good investment with returns of 21% and greater.

Very few literature sources were found addressing the question of the implications of regulating animal agriculture at the various levels of government. A task force sponsored by the State of Minnesota for the 1999 legislative session made the recommendation to consolidate regulation under the Department of Agriculture. Many Minnesota counties and townships, however, have acted to address feedlots at the local level in the past decade. A report by the Minnesota Legislative Auditor questions the MPCA capacity to adequately address feedlots while noting the wide variation in county feedlot programs.

CRITIQUE OF THE SCOPING DOCUMENT STUDY QUESTIONS

The study questions in the scoping document on the role of government divide into two broad categories. First, questions that ask for a listing or inventory of laws, regulations, rules, and funding sources. Second, questions the ask about the effect or impact of the laws, regulations, rules and funding sources.

Similar to the land use report, the role of government report went beyond traditional peer-reviewed literature to look for answers to the questions in the scoping document. Many scholarly and academic articles, white papers and other published articles were reviewed, but other sources used in legal and social-science research were also consulted. Other sources included: statutory language, law review articles, legal journals, and to a minor extent legislative history.

The study questions were subdivided into the following parts to facilitate research around the two broad categories listed above:

Question 1a: What are the government policies and programs directed at animal agriculture and human health as it is impacted by animal agriculture in Minnesota and other places including regulation, financial assistance and education or other incentives?
This question asks for a listing or inventory.

Question 1b: How effective are these actions in mitigating problems or encouraging desired outcomes? *This question concerns effects.*

Question 2a: What are the government actions and policies of the past, present and future that relate to economics, profitability, size and location; and what are the intended affects of these actions and policies?
This question asks for a listing with a description of intended affects.

Question 2b: How, and to what extent do the government actions and policies catalogued in question 2a. affect animal agriculture relating to economics, profitability, size and location? *This question concerns effects.*

Question 3: How are public funds for animal agriculture research, education and training currently allocated in Minnesota and how does the allocation of these funds impact the development of animal agriculture and Minnesota citizens as a whole?
This question asks for a listing and effects.

Question 4: What are the implications of regulating animal agriculture at the township, county, state and federal level? *This question asks for consideration of the effects of various levels of government taking on roles of varying responsibilities.*

REVIEW OF LITERATURE

Question 1a: What are the government policies and programs directed at animal agriculture and human health as it is impacted by animal agriculture in Minnesota and other places including regulation, financial assistance and education or other incentives?

The literature review for Question 1a. involves the cataloguing of government policies and programs and providing descriptions of the intent of the policies and programs. This section of the report lists federal and state policies and programs directed at animal agriculture, and briefly discusses local policies and programs. Local land use policies and programs are addressed more fully in the Land Use report.

DEFINITION OF LEGAL TERMS

To assist the reader in understanding this summary of laws, it may be helpful to describe some key legal terms:

"Statute" or "Act" refers to laws passed by legislative bodies such as the Minnesota Legislature or the United States Congress. Statutes or Acts are a higher level of law than rules, ordinances, and agency policies. Rules, ordinances, and policies must comply with controlling statutes or Acts or will be subject to reversal by courts. Minnesota statutes are cited by placing the appropriate number after the term "Minn. Stat. §" in this summary. Federal statutes or Acts are cited by referencing the title and section number of the United States Code, which is abbreviated as U.S.C.

"Rules" or "Regulations" are laws established by state or federal administrative agencies. Minnesota state agency rules are cited in this summary by placing the appropriate number after the term "Minn. Rule" or "Minn. R."

"Ordinances" are laws established by local units of government such as counties, townships, and cities. Each local unit of government will have its own method for numbering and citing ordinances.

Policies of state and federal administrative agencies generally do not have the force and effect of law. Rather, they provide guidance on the agencies' further interpretation and implementation of statutes and regulations.

MINNESOTA LAWS

I. Minnesota Pollution Control Agency

(Minn. Stat. §§ 115.01, *et seq.;* Minn. Stat. §§ 116.01, *et seq.;* Minn. R. 7020.0100, *et seq.;* Minn. R. 7050.0100, *et seq.*)

A. Water Pollution Controls

1. The Statute

a. Water Pollution Control Authority

The Minnesota Pollution Control Agency's authority to regulate potential pollution from feedlots is contained in Minn. Stat. §§ 115.03, *et seq.,* and 116.07. MPCA is granted the power to administer and enforce all laws relating to the pollution of any of the waters of the state. Minn. Stat. § 115.03, subd. 1(a). MPCA has the authority "to adopt, issue, reissue, modify, deny, or revoke, or enter into or enforce reasonable orders, permits, variances, standards, rules, schedules of compliance, and stipulation agreements, under such conditions as it may prescribe, in order to prevent, control or abate water pollution . . . ." Minn. Stat. § 115.03(e) and § 116.02, subd. 5. Water pollution includes, among many other things, the discharge of biological materials and agricultural waste. See Minn. Stat. § 115.01, subds. 13, 12, and 9.

b. National Pollution Discharge Elimination System Permits

State law authorizes the MPCA to participate in the National Pollution Discharge Elimination System (NPDES) program. (See Federal Law, Clean Water Act discussion below for description of the NPDES program.) Recent amendments to state statute contain specific requirements for NPDES permits for animal feedlots. 116.07, subd. 7c.

MPCA must issue NPDES permits for feedlots with 1,000 or more animal units according to the following schedule:

> (1) for application received after April 22, 1998, a permit for a newly constructed or expanded animal feedlot with 2,000 or more animal units must be issued as an individual permit;
>
> (2) for applications received after January 1, 1999, a permit for a newly constructed or expanded animal feedlot with between 1,000 and 2,000 animal units that is identified as a priority by the commissioner, using criteria established [pursuant to statutory provisions] must be issued as an individual permit; and
>
> (3) after January 1, 2001, all existing feedlots with 1,000 or more animal units must be issued an individual or general National Pollution Discharge Elimination System permit.

Minn. Stat. § 116.07, subd. 7c(a). By October 1, 1999, MPCA must issue a general NPDES permit for animal feedlots with between 1,000 and 2,000 animal units that are not identified under the above paragraph (a)(2).

There must be public notice and a public hearing before any general NPDES permit is issued. Minn. Stat. § 116.07, subd. 7c(c). Public notice is also required to the extent practicable before a individual NPDES permit is issued. This notice and hearing is to be concurrent with any pubic notice and comment for environmental review of the facility under Minn. Stat. § 116D, or for a conditional use permit when the local unit of government is the responsible unit for environmental review under § 116D.

Criteria for permitting are to be established by MPCA, in consultation with the feedlot and manure management advisory committee and other interested parties. MPCA is required to establish criteria for determining whether individual NPDES permits are required for feedlots under paragraphs (a)(2) and (3). (The feedlot and manure management advisory committee was established pursuant to Minn. Stat. § 17.136.)

c. Adoption of Feedlot Permit Rules

The MPCA is required by statute to adopt rules governing the issuance and denial of permits for livestock and poultry feedlots. Minn. Stat. § 116.07, subd. 7(g). These rules must not require feedlots with more than 10 but less than 50 animal units to obtain a permit, unless the operation is within a shoreland. *Id.* MPCA must cooperate closely with other governmental units in adopting and enforcing these rules. It is required to work with Minnesota Extension service, the department of agriculture, the board of water and soil resources, producer groups, local units of government, as well as with appropriate federal agencies such as the Natural Resources Conservation Service and the Farm Service Agency to notify and educate producers of the rules as they are being developed and at least every two years thereafter. Minn. Stat. § 116.07, subd. 7(f).

Until the new rules are implemented that provide for plans for manure storage structures, any plans for a liquid manure storage structure must be prepared or approved by a registered professional engineer or a USDA Natural Resources Conservation Service employee. Minn. Stat. § 116.07, subd. 7(j).

d. County Processing of Feedlot Permits

State law authorizes counties to seek approval from the pollution control agency to assume processing of applications for pollution control permits for livestock and poultry feedlot permits. Minn. Stat. §116.07, subd. 7. The MPCA will exercise supervising authority over counties that assume responsibility for processing feedlot permits. Minn. Stat. § 116.07 subd. 7(h). If a county assumes responsibility for processing such permits, the county board may delegate this authority to an appropriate county officer or employee. *Id.* Counties, if approved by MPCA to process feedlot permits, may take on such duties as distribution of application forms; receiving and examining applications and certifying to the MPCA that the facility will comply with applicable rules and standards or if it would not comply the type of variance needed; providing applicants needed assistance to complete the forms; and, at the option of the county board, denying, modifying, or imposing conditions upon, or revoking permits subject to review by MPCA. Minn. Stat. § 116.07, subd. 7 (a) and (b).

e. Notice of Application for Feedlot Permits

Any person who applies to the MPCA or a county board for a permit to construct or expand a feedlot with a capacity of 500 animal units or more must, no later than ten business days after the application is submitted provide notice to each resident and each owner of real property within 5,000 feet of the perimeter of the proposed feedlot. The notice may be made in person, by first class mail, or in a newspaper of general circulation within the affected area. The notice must include the type of livestock and the proposed capacity of the feedlot. This notice requirement is satisfied by an equal or greater requirement for a county conditional use permit. Minn. Stat. § 116.07, sub. 7a.

f. Feedlot Inventory Notification and Public Meeting Requirements

State agencies and local units of government which conduct an inventory or survey of livestock feedlots must publicize notice of the inventory in a newspaper of general circulation and in other media as appropriate. The notice must state the dates of the inventory, the information that will be requested, how the information will be provided to the public, and the date of a public meeting regarding the inventory. Minn. Stat. § 116.07, subd. 7b(1). Any local unit of government that intends to conduct an inventory or survey of livestock feedlots must hold at least one public meeting before beginning the inventory or survey. A state agency must hold at least 4 public meeting outside the seven county metro area before beginning a survey or inventory of livestock feedlots. Minn. Stat. § 116.07, subd. 7c.

2. The Rules

a. Feedlot Rules

The MPCA rules that "govern the storage, transportation, disposal, and utilization of animal manure and the application for and issuance of permits and certificates of compliance for construction and operation of animal manure management and disposal or utilization systems for the protection of the environment" are at Minn. R. 7020. Effluent limitations for discharges of pollutants from animal feedlots to waters of the state are at Minn. R. 7050.0215. A detailed analysis of these rules is not included here because MPCA is in the process of rewriting its feedlot rules. New final rules are expected to be issued prior to the completion of the Generic Environmental Impact Statement on Animal Agriculture. These new final rules should be incorporated into this report when they are adopted. New proposed rules are expected to be published sometime during the winter of 1999-2000. These rules should become final and effective sometime during the summer of 2000. The commissioner of the pollution control agency must submit updated feedlots permit rules to the legislature by December 1, 1999. These rules must not become effective prior to April 1, 2000. Act of May 25, 1999, Chapter 231, 1999 Minn. Sess. Laws, Section 193.

b. Water Quality Standards Rules

Sections 7050.0130 to 7050.0227 of the Minnesota Rules contain the water quality standards rules. These rules apply to all waters of the state—both surface and underground. The rules of this chapter apply to all point source and nonpoint source discharges. Key definitions of terms are contained in Minn. Rule § 7050.130. This section includes definitions for "waters of the state," "sewage," "industrial waste" and "other wastes," "nonpoint source," "physical alternation," "surface waters," and "wetlands."

Section 7050.0150 sets out the purposes and general guidelines for determination of water quality condition and compliance. It states that "the intent of the state is to protect and maintain surface waters in a condition which allows for the maintenance of all existing beneficial uses. The condition of a surface water body is determined by the physical, chemical, and biological qualities." Section 7050.0170 acknowledges that natural conditions of some waters may exceed the established standards. This section establishes that "where natural background levels do not exceed applicable standards, the addition of pollutants from human activity resulting from point and nonpoint source discharges shall be limited such that, in total, the natural background levels and the additions from human activity shall not exceed the standards."

Section 7050.0180 establishes the policies for nondegradation of outstanding resource value waters. The policy states:

> The agency recognizes that the maintenance of existing high quality in some waters of outstanding resource value to the state is essential to their function as exceptional recreational, cultural, aesthetic, or scientific resources. To preserve the value of these special waters, the agency will prohibit or stringently control new or expanded discharges from either point or nonpoint sources to outstanding

> resource value waters.

Minn. R. 7050.0180, subpt. 1.

Section 7050.0180 includes definitions of "outstanding resource value waters, "new discharge," and "expanded discharge." Subpart 3 establishes a prohibition on discharges in to certain listed waters including Department of Natural Resources scientific and natural areas which are listed in Subpart 4. Restricted discharges are covered by Subpart 6.

The provisions for nondegradation of all waters is set out in Minn. R. 7050.0185. this program's policy is stated as follows:

> The potential capacity of the water to assimilate additional wastes and the beneficial uses inherent in water resources are valuable public resources. It is the policy of the state of Minnesota to protect all waters from significant degradation from point and nonpoint sources and wetland alterations, and to maintain existing water uses, aquatic and wetland habitats, and the level of water quality necessary to protect these uses.

Minn. R. 7050.0185, subpt. 1.

Subpart 2 of this section contains definitions of key terms. Minimum treatment requirements are set out in Subpart 3. Additional requirements for significant discharges are contained in subpart 4. Subpart 5 sets out how determination of significance is to be made. Subparts 6, 7, 8, and 9 of this section of the rules set out baseline quality standards, incremental expansion requirements, determination of reasonable control measures for significant discharges, and address physical alternations of wetlands, respectively.

The wetland mitigation policy states that "it is the policy of the state to protect wetlands from significant adverse impacts on wetland designated uses. Wetland mitigation maintains nondegradation of wetland designated uses. Minn. R. 7050.0186, subpt. 1. Wetland mitigation principles are set out at subpart 2 of this section. The method for wetland dependency determination, impact avoidance standards, impact minimization standards, and impact compensation provisions are addressed in the remainder of Minn. R. 7050.0186.

Standards and procedures for granting variances from these water quality standards rules are contained at Minn. R. 7050.0190. Water use classifications for the waters of the state are at Minn. R. 7050.0200. General standards for dischargers to waters of the state are set out at Minn. R. 7050.0210, and facility standards are addressed at § 7050.0211.

The specific effluent limitation standards for feedlots are contained at Minn. R. 7050.0215. Subpart 1 of this section sets out key term definitions. Subpart 2 establishes the effluent limitation for a discharge as follows:

> A. Any person discharging pollutants to surface waters of the state from an animal feedlot or manure storage area who is not regulated by federal requirements under part 7050.0212, subpt. 1, shall comply with the following limitations after allowance for

pollutant removal by a treatment works: 5-day biochemical oxygen demand—25 milligrams per liter (arithmetic mean of all samples taken during any calendar month.)

If the discharge is directly to or affects a lake or reservoir, the person discharging the pollutants shall comply with the nutrient control requirements of part 70050.0211, subpt. 1.

B. The effluent limitations in item A are not applicable whenever rainfall events, either chronic or catastrophic, cause an overflow from an animal feedlot or manure storage area designed, constructed, and operated:

(1) to meet the effluent limitations in item A for rainfall events less than or equal to a 25-year, 24-hour rainfall event for that location; or

(2) to collect and contain the runoff from a 25-year, 24-hour rainfall event for that location.

3. Other Policies and Guidelines

MPCA makes available to the public several other documents that it uses in setting policy regarding animal feedlots. These documents include:

a. USDA, Soil Conservation Service, *Conservation Choices: Your guide to 30 conservation and environmental farming practices,* U. S. Gov't Printing Office: 1994-546-791.

b. *Minnesota Pollution Control Agency Land Application of Waste Site Review Checklist.*

c. Minnesota Pollution Control Agency, *Evaluation of the Need for an Environmental Assessment Worksheet*, 1/28/98.

d. Chastain, John P., Schmidt,, David, *Mini-Pits: A Short-Term Manure Storage Alternative For Freestall Dairy Facilities That Haul Daily or use Sand Bedding,* Agricultural Engineering Update: Department of Biosystems and Agricultural Engineering, College of Agricultural, Food, and Environmental Sciences, Minnesota Extension Service, University of Minnesota, August 10, 1995, AEU-9.

e. Minnesota Pollution Control Agency, *Facts about the Mixing of Animal Waste with Domestic or Sanitary Waste.*

f. Chastain, John P., Jacobsen, Larry D., *Site Selection for Animal Housing and Waste Storage Facilities*, Agricultural Engineering Update, Department of Agricultural Engineering, Minnesota Extension Service, University of Minnesota, June 20, 1994, AEU-6.

g. State of Minnesota Board of Electricity, *NEC Section 547-8(b), Concrete Embedded Elements, Equipotential Planes, and voltage Gradients,* May 13, 1996.

h. Minnesota Pollution Control Agency, *Organic Waste Storage Structures Review of Designs and Specifications*, Draft May 6, 1994.

i. Minnesota Pollution Control Agency, *Concrete Pit Requirements*, April 1994.

j. *Pond Sealing and Lining: Flexible Membrane Lining*, SCS, June 1984.

k. Minnesota Board of Water and Soil Resources, *Feedlot Inventory Guidebook,* June 1991.

l. Minnesota Pollution Control Agency, Water Quality Division, *Sampling Procedures for Ground Water Monitoring Wells*, July 1997.

m. Fact sheets:

- *Number of animal units that will producer 100,000 lbs. of available nitrogen, depending on animal type and manure storage systems.*
- *Various Methods of Application, Continuous Corn, Every Year Application, 100,000 lbs. N available after storage.*
- *First year acreage needs vs. long term acreage needs.*
- *Various Methods of Application, Corn/Soybean Rotation, Every Year Application (crop nutrient "uptake" basis), 100,000 lbs. N available after storage*
- *Various Methods of Application, Corn/soybean Rotation, Every Other Year Application (crop nutrient "needs" basis), 100,0000 lbs. N Available after storage.*
- *Broadcast application with no incorporation, Corn/Alfalfa rotation, apply four out of five years (crop nutrient "uptake" basis), 100,000 lbs. N available after storage.*
- *Soil Conservation Service Broadcast application with no incorporation, Corn/Alfalfa rotation, apply one out of five years (crop nutrient "needs" basis), 100,000 lbs. N available after storage.*
- *Comparison of acres needed depending on crop rotation and application frequency.*
- *Suggestions for determining number of acres needed.*

4. Enforcement

For several years MPCA used the "Compliance Management Guide" to provide guidance on how to proceed with enforcement actions on water permitting issues. MPCA is now in the process of developing a multi-media enforcement response guidance document, referred to as the "Enforcement Response Plan." Once this plan is complete, MPCA will use it as a guide for multi-media enforcement proceedings.

The report that gives the most recent information about enforcement of water and air quality matters related to feedlots is the January 1999 legislative audit report discussed in more detail below. (Noble 1999.) MPCA has also compiled the "MPCA Enforcement and Penalty Summary," a three page report providing numbers for all enforcement actions taken by the agency as a whole between 1975 and 1998. This document includes numbers regarding notice of violations, administrative penalty orders, stipulation agreements, and total penalties assessed.

B. Air Pollution Controls

1. The Statute

Some forms of potential air pollution from animal feedlots may also be regulated by the MPCA. This agency has the responsibility for adopting and enforcing standards for air quality. Minn. Stat. § 116.07, subd. 2. in developing these air standards the MPCA must give consideration to the fact that the quantity or characteristics of air contaminants or the duration of their presence at acceptable levels may be different for different areas of the state. *Id.* Other factors to be considered in setting these standards are detailed in the statute. *Id.*

Persons who control the source of emissions must notify MPCA immediately of "excessive or abnormal unpermitted emissions that: (1) may cause air pollution endangering human health; (2) may cause air pollution damaging property; or cause obnoxious odors constituting a public nuisance." Minn. Stat. § 116.061, subd. 1. A person required to notify the agency of the emission must also take "immediate and reasonable" steps to abate the emission. Minn. Stat. § 116.061, subd. 2. "Emissions from an agricultural operation deemed not a nuisance under section 561.19, subdivision 2" is exempt from this notice and abatement requirement. Minn. Stat. § 116.061, subd. 3. See "Nuisance Liability Limitations for Animal Agriculture (Right to Farm Law)" below for more detailed discussion of Minn. Stat. § 561.19, subd. 2.

There are specific statutory provisions relating to hydrogen sulfide emitted from animal feedlots. MPCA must monitor and identify potential livestock facility violations of the state ambient air quality standards for hydrogen sulfide. MPCA must establish a protocol for responding to citizen complaints about feedlot odor and its hydrogen sulfide component. The protocol must include appropriate use of portable monitoring equipment that enable staff to follow plumes. Minn. Stat. § 116.0713(1). When a livestock feedlot is found to have violated the ambient hydrogen sulfide standards, the MPCA is require to take appropriate action to ensure compliance. This action may include use of technical assistance and enforcement and penalty authorities of the agency. Minn. Stat. § 116.0713(2).

2. The Rules and Agency Policies

The MPCA rules that establish ambient air quality standards for hydrogen sulfide are at Minn. R. 7009.0080. This rule provides that for hydrogen sulfide the ambient air quality standard primary standards is 0.05 ppm by volume (70.0 micrograms per cubic meter) based on a one-half-hour average not to be exceeded more than two times per year. The rule also provides for a 0.02 ppm by volume (42.0 micrograms per cubic meter) based on one-half-hour average not to be exceed over two times in any five consecutive days. Minn. R. 7009.0060 requires that the commissioner approve the measurement methodology for hydrogen sulfide.

MPCA created a protocol for establishing a field operating procedure for MPCA staff during emission sampling to determine whether the subject feedlot is in compliance with the state ambient air quality standard for hydrogen sulfide. It will also be used to gather field data for research on the effectiveness of various technologies.

3. Enforcement

MPCA uses the "Enforcement Response Plan" as a guide for air quality enforcement actions. Air quality enforcement actions will also be addressed in the multi-media "Enforcement Response Plan" now being developed by MPCA.

In addition, MPCA issued a report to the Minnesota Legislature on the feedlots hydrogen sulfide. This report includes data on air screening and complaints; compliance/enforcement status update; total number of sites monitored with continuous air monitoring; and a breakdown of the enforcement/compliance activities by facility.

II. Environmental Impact Statements

(Minn. Stat. §§ 116D.01, *et seq.;* Minn. R. 4410)

A. The Statute

MPCA permitting of a feedlot could amount to major government activity with significant environmental effects so as to require an assessment as to whether an environmental impact statement must be completed prior to the permitting. The state statute controlling environmental impact statements and environmental assessment worksheets is at Minn. Stat. §§ 116D.01, *et seq.*

B. The Rules

The rules implementing the environmental review process are found in the Environmental Quality Board rules at Minn. R. 4410. These rules require that proposed government actions which may have the potential for significant environmental effect undergo environmental review. The rules assign responsibility for the environmental review to the responsible government unit (RGU) and provide mandatory categories of projects where environmental review is required. There are two categories of review: 1) the Environmental Assessment Worksheet (EAW), and 2) the Environmental Impact Statement (EIS). The EAW is used to determine if there exists a potential for significant environmental effect. If so an EIS may be required. The EIS is a thorough study of environmental, social and economic impacts, and comparisons of the proposed project with reasonable alternatives. The rules also allow for twenty-five persons to petition to request an responsible government unit to complete an Environmental Assessment Worksheet.

III. Minnesota Environmental Rights Act

(Minn. Stat. §§116B.01, ***et seq.***)

The Minnesota Environmental Rights Act (MERA) provides citizens, governmental bodies, and business entities the right to sue to protect air, water, land, and other natural resources located within the state from pollution, impairment, or destruction in some instances.

A. Purpose of Act

The purposes of the Act are explicitly stated as follows:

> The legislature finds and declares that each person is entitled by right to the protection, preservation, and enhancement of air, water, land and other natural resources located within the state and that each person has the responsibility to contribute to the protection, preservation, and enhancement thereof. The legislature further declares its policy to create and maintain within the state conditions under which human beings and nature can exist in productive harmony in order that present and future generations may enjoy clean air and water,

> productive land, and other natural resources with which this state has been endowed. Accordingly, it is in the public interest to provide an adequate civil remedy to protect air, water, land and other natural resources located within the state from pollution, impairment, or destruction.

Minn. Stat. § 116B.01.

B. Civil Action Authorized

The MERA authorizes any person residing in the state; the attorney general; any instrumentality or subdivision of the state or of a political subdivision thereof; and various types of business entities with shareholders, members, or partners residing in Minnesota to sue in state court seeking declaratory and equitable relief for the protection of the air, water, land or other natural resources located within the state from pollution, impairment, or destruction. This provision applies both to publicly and privately owned property. However, this section does not authorize claims against a person who owns or leases the land for acts taken by the person pursuant to a permit or license issued by the owner of the land to the person which do not and cannot reasonably be expected to pollute, impair, or destroy any other air, water, land, or other natural resources located within the state. The provision also does not authorize a lawsuit based on action taken pursuant to any environmental quality standard, limitation, rule, order, license, stipulation agreement, or permit issued by the pollution control agency, department of natural resources, department of health or department of agriculture. Minn. Stat. § 116B.03, subd. 1.

C. Definition of Key Terms

Definitions of key terms used in MERA are contained at Minn. Stat. § 116B.02. The terms "person," "non-resident individual," "natural resources," "pollution, impairment, or destruction" are all defined in detail.

"Natural resources" is defined to include but not be limited to "all mineral, animal, botanical, air, water, land, timber, soil, quietude, recreational and historical resources. Scenic and esthetic resources shall also be considered natural resources when owned by any governmental unit or agency." Minn. Stat. § 116B.02, subd. 4.

"Pollution, impairment or destruction" included "any conduct by any person which violates. or is likely to violate, any environmental quality standards, limitation, rule, order, license, stipulation agreement, or permit of the state or any instrumentality, agency, or political subdivision thereof which was issued prior to the date the alleged violation occurred or is likely to occur or any conduct which materially adversely affects or is likely to materially adversely affect the environment, provided the 'pollution, impairment or destruction' shall not include conduct which violated, or is likely to violate, any such standard, limitation, rules, order, license, stipulation agreement or permit solely because of the introduction of an odor into the air." Minn. Stat. § 116B.02, subd. 5.

D. Farm Exemptions

MERA appears to exempt certain farming entities from suit under its provisions. While the Act does not explicitly state that certain defined farming entities are exempt, it does include them in the Act's definition. The Supreme Court of Minnesota has interpreted the Act to provide such exemptions. *County of Freeborn by Tuveson v. Bryson*, 243 N.W.2d 316 (Minn. 1976). The Act contains the following definitions:

> "Family farm" shall mean any farm owned by a natural person, or one or more natural personas all of whom are related within the third degree of kindred according to the civil law, at least one of whose owners reside on or actively operates said farm. Minn. Stat. § 116B.02, subd. 6.
>
> "Family farm corporation" means a corporation founded for the purpose of farming and owning agricultural lands, in which the majority of the voting stock is held by, and the majority of the stockholders are, members of a family related to each other within the third degree of kindred according to the rules of civil law, and at least one of whose stockholders is a person residing on or actively operating the farm, and none of those stockholders are corporations. Minn. Stat. § 116B.02, subd. 7.
>
> "Bona fide farmer corporation" means an association of two or more natural persons, one of which, if two persons are so associated, or the majority of which, if more than two persons are so associated, reside on, or are actively operating a farm. Minn. Stat. § 116B.02, subd. 8.

E. Relief in Lawsuit

In any case brought under MERA, the court is empowered to grant declaratory relief, temporary and permanent equitable relief, or may impose such conditions upon a party as are necessary or appropriate to protect the air, water, land or other natural resource located in Minnesota from pollution, impairment, or destruction. The court may require the placing of a bond if temporary relief is granted in order to protect the parties if permanent relief is not ultimately granted. Minn. Stat. § 116B.07.

F. Procedures for Lawsuit

Minnesota Statutes § 116B.03, subds. 2, 3, 4, and 5 set out procedural matters in lawsuits filed under MERA. These subdivisions establish notice and service provisions for any lawsuit filed; authorize the attorney general to intervene in cases filed by others; and establish the finality of the judgments and their effect on agency actions. The burden for proving up the claims in the lawsuit are set out at Minn. Stat. § 116B.04. Courts are authorized to require bonds in some instances. See Minn. Stat. §116B.06. In some instances Courts are required to remit the case to administrative proceedings before finally ruling, as explained in Minn. Stat. § 116B.08.

G. Intervention in Administrative Proceedings

MERA also authorizes residents of the state, the attorney general, political subdivisions of the state, and various business entities to intervene in administrative, licensing, or other similar proceedings and in judicial review of such proceedings, involving action that has caused or is likely to cause pollution, impairment, or destruction of the air, water, land or other natural resource within Minnesota. Minn. Stat. §§ 116B.09 and 116B.10.

H. Actions Against Agencies

MERA also authorizes Minnesota residents, the attorney general, political subdivisions of the state, and various business entities to file lawsuits against the state or any agency thereof in district court for declaratory and equitable relief where the nature of the action is a "challenge to an environmental quality standard, limitation, rule, order, license, stipulation agreement, or permit promulgated or issued by the state or agency. Minn. Stat. § 116B.10.

IV. Department of Natural Resources—Water Appropriation Permits

(Minn. Stat. § 103G.271; Minn. R. 6115.600-.680)

In some instances, large feedlots may be required to obtain water appropriation permits from the Department of Natural Resources. The statutory authority for water appropriation permits is found at Minn. Stat. § 103G.271. The water appropriation and use permit rules are located at Minn. R. 6115.0600-.0680.

The purpose of the water appropriation permit rules "is to provide for the orderly and consistent review of permit applications for appropriation and use of waters of the state in order to conserve and utilize the water resources of the state in the public interest." Minn. R. 6115.0600. These rules "set forth the minimum standards and criteria pertaining to the regulation, conservation, and allocation of the water resources of the state, including the review, issuance, and denial of water appropriation applications and the modification, suspension, or termination of existing permits." Minn. R. 6115.0610.

Feedlots that will use water at a rate exceeding 10,000 gallons per day or 1,000,000 gallons per year are required to obtain a water appropriations permit. Minn. R. 6115.0620. Procedures for applying for water appropriations permits are found at Minn. R. 6115.0630. The standards for review of and the procedures for DNR actions on permit applications are found at Minn. R. 6115.0670. Minnesota Rule 6115.680 sets out additional requirements for water to be used in agricultural irrigation.

V. Township and Cities Planning and Zoning Authority (Minn. Stat. §§ 462.01, *et seq.*; Minn. Stat. §§ 366.01, *et seq.*)

Municipalities, which include cities and townships, have the authority to develop and implement comprehensive and land use plans under Minnesota Statute Chapter 462.351, *et seq.* These statutory provisions set out the planning and zoning authorities in detail. The following is a summary of some of the highlights of this authority.

A. Planning Authority

Through the use of this authority, municipalities have the power to plan for future development and use of land. Minnesota Statute § 462.351 lists the areas in which the municipalities can use its planning and development authority:

1. To insure a safer, more pleasant, and more economical environment for residential, commercial, industrial, and public activities;

2. To preserve agricultural and other open lands; and

3. To promote the public health, safety, and general welfare.

Using planning authorities, municipalities develop comprehensive plans that set out policies, goals, standards, and maps for guiding the physical, social, and economic development, both public and private, for the municipality. Minn. Stat. § 462.352, subd. 5. These comprehensive plans may include a land use plan, including proposed densities for development, a community facilities plan, a transportation plan, and recommendations for plan execution.

B. Authority to Implement Plan through Ordinances

Once a comprehensive plan is completed, the municipalities may execute the plan by enacting official controls such as zoning ordinances. Minn. Stat. § 462.357, subd. 1. Such ordinances may include regulation of many factors that may affect animal agriculture. Relevant excerpts from the statute include authority to regulate the "earth's surface, in the air space above the surface, and in the subsurface areas . . . the location, height, width, bulk, type of foundation . . . size of buildings and other structures . . . and the uses of land for trade, industry, residences . . . agriculture . . . soil conservation, water supply conservation, conservation of shorelands . . . and other purposes." *Id.* Such zoning ordinances must be consistent with the policies and guidelines established in the comprehensive plan.

No zoning ordinances or amendments thereto may be adopted until a public hearing has been held by the municipality's planning agency or governing body. Minn. Stat. § 462.357, subd. 3.

This planning and zoning authority gives municipalities the authority to regulate animal agriculture in many ways possibly including: (1) the construction and placement of feeding buildings and structures; (2) restrictions designed to ensure the maintenance of property values and use and enjoyment of neighboring properties; (3) protection of public health from airborne

odors, gases, or pathogens; (4) for conservation of soil or water supply resources; and (5) density of development.

C. Interim Ordinance Prohibiting Development

To ensure that municipalities have the opportunity to complete their comprehensive plans and develop appropriate zoning ordinances before inappropriate development occurs, the legislature has granted municipalities the authority to issue interim ordinances that prohibit development until the planning process is completed and zoning ordinances are issued. Minn. Stat. § 462.355, subd. 4. However, not all interim ordinances amount to moratoria on development. Whether an interim ordinance acts as a moratoria on development is dependent on the way the ordinance is drafted. Such an interim ordinance may act as a moratorium on the type of development listed in the ordinance. The interim ordinance authority is designed to allow the municipality time to conduct studies, hold hearings, and develop a comprehensive plan and enact zoning ordinances without having land use development during this time undercut the planning process. The interim ordinance is not a zoning ordinance and may be enacted without a public hearing on a simple majority vote. It may be in place for up to 12 months and may be renewed for up to an additional 18 months.

In a recent decision involving a proposed livestock feedlot, the Minnesota Court of Appeals upheld a township interim ordinance when it was applied to prevent the building of the only known large-scale livestock facility being proposed in the township at the time the ordinance was passed. See *Duncanson v. Board of Supervisors of Danville Township,* 551 N.W.2d 248 (Minn. App. 1996). In another case involving an interim township ordinance, in July 199 the Minnesota Court of Appeals upheld a township's denial of a conditional use permit for a large-scale hog confinement facility. *Berscheit v. Town of Grey Eagle, Minnesota*, CO-98-2298 (Minn. Ct. App. July 13, 1999) (unreported case). The court upheld the lower court's decision that the 1000-head facility was a commercial operation and, therefore, must meet the zoning setback limitation for such facilities. The court stated that "the district court did not err in granting summary judgment on the basis of a 'size' differential in the zoning ordinance rather than determining whether the Berscheits operated a 'family farm' exempt from the ordinance." Because the proposed operation could not meet the setback limitations, it was proper for the township to deny the conditional use permit. The court did not address the challenge to the interim ordinance because it was not necessary since the proposed operation could not meet the existing zoning ordinance setback provisions.

D. Township Planning and Zoning Authority

Township planning and zoning authority is also addressed at Minnesota Statutes §§ 366.10-.18. In part, these provisions authorize town boards of supervisors to submit to legal voters of the town at an annual or special town meeting the question whether the board shall adopt land use and zoning regulations. These provisions also address the types and purposes of such zoning and land use regulations.

E. Restrictions on Municipal Authority

Some types of municipal zoning ordinance provisions may be unenforceable even though they were properly established through the planning process and were based on a rational analysis of information and evidence gathered in that process.

1. Impact of County Ordinance

Town zoning ordinances may not be inconsistent with or less restrictive than standards in ordinances issued by the county. However, townships can adopt zoning ordinances that are more restrictive than those adopted by the county. Minn. Stat. § 394.33, subd. 1.

2. Preemption by State Law

Some types of township ordinance provisions may be preempted by state law. Preemption occurs when the state so completely regulates an area that there is no room left for local regulation. *Mangold Midwest Co. v. Village of Richfield,* 143 N.W.2d 813 (Minn. 1966). Given the broad authority of local governments to legislate to protect the health, safety, and welfare of their residents, preemption exists only where: (a) the subject matter has been so fully and completely covered by general law as to clearly indicate that it has become exclusively a matter of state concern; (b) the subject matter has been partially covered by general law couched in such terms as to indicate clearly that a paramount state concern will not tolerate further or additional local action; or (c) the subject matter has been partially covered by general law, and the subject is of such a nature that the adverse effect of a local ordinance on the transient citizens of the state outweighs the possible benefit to the municipality. *Mangold Midwest Co.,* 143 N.W.2d at 820 (citations omitted).

Four factors are considered in evaluating a preemption claim: (1) What is the "subject matter" which is to be regulated? (2) Has the subject matter been so fully covered by state law as to have become solely a matter of state concern? (3) Has the legislature in partially regulating the subject matter indicated that it is a matter solely for state concern? (4) Is the subject matter itself of such a nature that local regulation would have unreasonably adverse effects upon the general populace of the state? *Mangold Midwest Co.,* 143 N.W.2d at 820.

The Minnesota Court of Appeals has rejected a township ordinance regulating feedlots under the preemption theory. The court held that the Minnesota Pollution Control Agency (MPCA) feedlot rules were so comprehensive as to fully cover the area of "control of pollution from manure produced in animal feedlots." The court also held that allowing townships to establish individual pollution control standards would result in "a patchwork of different rules" that "would be burdensome and would have a detrimental effect on the efficient operation of the state's agricultural industry." As a result, the court held that a Crooks Township ordinance establishing setbacks, requiring a bond, and establishing manure application rates was preempted by state law. See *Board of Supervisors v. ValAdCo,* 504 N.W.2d 267 (Minn. Ct. App. 1993), *pet. for rev. denied* (Minn. Sept. 30, 1993). (This case did not involve an ordinance that was enacted through the planning and zoning authorities discussed here. It is not clear whether a similar ordinance

established through such a procedure would withstand a preemption challenge.)

A Minnesota District Court has held that a Stanton Township ordinance that established setback distances from residences for livestock feedlots was not preempted by the MPCA feedlot laws because the purpose of the ordinance was to regulate "the broader social values inherent in zoning regulation generally." See *Gustafson v. Board of Supervisors,* No. 25-C7-95-1446 (1st Dist. Minn. Apr. 26, 1996). The Minnesota Court of Appeals recently issued a decision in that case without reaching the preemption or conflict issues. *Gustafson v. Board of Supervisors of Stanton Township,* C9-96-1372 (Minn. Ct. App. Feb. 4, 1997). The court of appeals rejected the Stanton township zoning ordinance objecting to the rationale provided by the township for key provisions in the ordinance. The court rejected the ordinance because the setback and animal unit numbers were not "supported by any rational basis related to the promotion of the public health, safety, and welfare." *Id.* at 8.

In a more recent case, the Minnesota Court of Appeals held that a township zoning ordinance that contained setback provisions from adjoining property, a township road, and an occupied residence was designed to minimize the impact of odors on neighbors from a feedlot and was a proper exercise of the township's authority. *Canadian Connection v. New Prairie Township*, 581 N.W.2d 391 (Minn. Ct. App. 1998). The court held that the ordinance provision establishing setbacks was not preempted by state law because (1) it was designed to reduce the impact of odors on neighbors not to set air quality standards; (2) MPCA does not have specific setback requirements for feedlots and had not established air quality standards for feedlots; and (3) implementation of the ordinance would not have an unreasonably adverse effect on the general populace. The court also held that the township ordinance did not conflict with state law because MPCA's odor management plan requirement for the proposed expanded operation had a different purpose than the setback requirements of the township ordinance. Therefore, the two requirements could be reconciled and were not in conflict. Finally, the court that the township properly established a rational relationship between regulating the location of feedlots and addressing its residents' concern regarding odor from feedlots.

3. Conflict With State Law

Township zoning ordinance provisions may be unenforceable if they conflict with state laws. Conflict exists between a municipality's ordinance and a state law when they contain express or implied terms that are irreconcilable with each other. Courts have held that a conflict exists where the ordinance permits what the statute forbids or when the ordinance forbids what the statute *expressly* permits. *Mangold Midwest Co.,* 143 N.W.2d at 818-19; *Power v. Nordstrom,* 184 N.W.2d 967, 969 (Minn. 1921). However, it is generally recognized that there is no conflict when the ordinance, though different from the statute, is merely additional and complementary to or in aid and furtherance of the statute. *Mangold Midwest Co.,* 143 N.W.2d at 817, citing *Clarke Plumbing and Heating, Inc.,* 56 N.W.2d 667, 671-72 (Minn. 1952).

In the *ValAdCo* (Crooks Township) decision, the court of appeals also held that the township ordinance could not be enforced because it was in conflict with the MPCA feedlot laws. The court found a conflict because the ordinance's setback provisions would have prohibited building

of the proposed hog facility when MPCA had already granted a feedlot permit. See *Board of Supervisors v. ValAdCo,* 504 N.W.2d 267 (Minn. Ct. App. 1993), *pet. for rev. denied* (Minn. Sept. 30, 1993).

In the *Gustafson* (Stanton Township) case, the district court found that there was a conflict between the ordinance and the state law because the ordinance would have prohibited the facility while the state law would have allowed it. The district court, however, found that this conflict did not require striking down the township ordinance because the ordinance was designed to minimize the impact of odors from the feedlot and MPCA had conceded that its odor regulation was legally unenforceable and admitted that it had no intention of preempting local regulations on odors saying that "zoning is an essential part of local government's response to odor issues." See *Gustafson v. Board of Supervisors,* No. 25-C7-95-1446 (1st Dist. Minn. Apr. 26, 1996), *reversed on other grounds, Gustafson v. Board of Supervisors of Stanton Township,* C9-96-1372 (Minn. Ct. App. Feb. 4, 1997). As discussed above, in *Canadian Connection v. New Prairie Township*, 581 N.W.2d 391 (Minn. Ct. App. 1998), the court of appeals also held that the township ordinance setting setback requirements for commercial feedlots did not conflict with state law because MPCA's odor management plan requirement for the proposed expanded hog confinement operation had a different purpose than the setback requirements of the township ordinance.

VI. County Planning and Zoning Authority

(Minn. Stat. §§ 394.01, *et seq.*)

County Boards of Commissioners also have the power to regulate animal agriculture through comprehensive planning and zoning ordinances for purposes of promoting the health, safety, morals, and general welfare of the community. The county planning and zoning procedures are spelled out in detail in Minnesota Statutes §§ 394.21-.37. State statute explicitly permits counties to adopt by ordinance standards for animal feedlots that are more stringent than pollution control agency rules. Minn. Stat. § 116.07, subd. 7(k).

A. Comprehensive and Community-Based Planning

The county board has the power to adopt comprehensive plans by ordinance. Once a comprehensive plan is adopted by ordinance, that ordinance must be the basis of the official controls implemented through zoning ordinances. See Minn. Stat. §§ 394.23 and 394.24.

Counties are encouraged by statute to prepare and implement a community-based comprehensive plan. The procedures and goals of community-based planning are set out in Minnesota Statutes § 4A.08 and specific procedures for community-based planning by counties are addressed at Minnesota Statutes §394.232. The community-based planning provisions in Minn. Stat. §§ 4A.08, 4A.09, and 4A.10 will sunset on July 1, 2001, pursuant to 1999 Minnesota Session Laws, ch. 250, art. 1, para. g.

B. Zoning Ordinance Authority

Forms of control that may be exercised through county zoning ordinances are described at Minnesota Statutes § 394.25. There are many types of control authorized that may impact animal agriculture. For example, counties have the authority to establish "districts within which the use of land or the use of water or the surface of water pursuant to section 86B.205 for agriculture . . . residence, industry, trade, soil conservation, water supply conservation, surface water drainage and removal, conservation of shorelands . . . may be by official controls encouraged, regulated, or prohibited . . . ." See Minn. Stat. § 394.25, subd. 2. Other authorized types of official controls that may impact animal agriculture include but are not limited to those "applied to wetlands preservation . . . protection of groundwater, protection of floodplains as defined by section 103F.111, protection of wild, scenic, or recreational rivers as defined by section 103F.311 and 103F.315, protection of slope, soils, unconsolidated materials or bedrock from potentially damaging development, preservation of . . . essential wildlife habitat . . . and preservation of agricultural land." *Id.* Within zoning districts zoning ordinances or maps may be adopted designating or limiting the location, height, width, bulk, type of foundation . . . size of, and the specific uses for which dwellings, buildings, and structures may be erected or altered . . . protective measures necessary to protect the public interest but not limited to controls relating to appearance . . . hours of operation, and other aesthetic performance characteristics . . . ." *Id.*

C. Feedlot Zoning Ordinances

Minnesota Statute § 394.25, subd. 3c, requires that any county proposing to adopt a new feedlot ordinance or amend an existing feedlot ordinance must notify the pollution control agency and the Commissioner of Agriculture at the beginning of the process. Prior to the final approval of a feedlot ordinance, the county may submit the proposed ordinance to the pollution control agency and to the Commissioner of Agriculture and request review, comment, and preparation of a report on the environmental and agricultural effects from specific provisions in the ordinance. Minn. Stat. § 394.25, subd. 3c(b). The requested report may include: (1) any recommendation for improvements in the ordinance; and (2) the legal, social, environmental, or scientific justification for each recommendation under clause (1). Minn. Stat. § 394.25, subd. 3c (c).

A local ordinance that contains a setback for new feedlots from existing residences must also provide for a new residence setback from existing feedlots located in areas zoned agricultural at the same distances and conditions specified in the setback for new feedlots, unless the new residence is built to replace an existing residence. A county may provide a variance from this requirement under § 394.27, subd. 7.

D. Amendments to Ordinances

An amendment to a zoning ordinance or official control may be initiated by the county board or the planning commission, or by petition of affected property owners as defined in the official controls. Minn. Stat. § 394.25, subd. 10. Any amendment not initiated by the planning commission must be referred to the planning commission for a study and report. The county board may not act on the amendment until it has received the recommendation from the planning commission.

E. Public Hearings

In addition to public hearings required prior to the adoption by ordinance of any comprehensive plan or amendments thereto or of any official control or amendment thereto, public hearings shall be held before any conditional use permit, any variance, or any proposal for subdivision is approved or denied. Minn. Stat. § 394.26, subd. 1a. Public notice requirements for these public hearings are spelled out at Minn. Stat. § 394.25, subd. 2.

F. Boards of Adjustment

Minnesota Statutes require that whenever a county adopts official controls, it must establish a board of adjustment that will have the authority to issue variances, decide appeals of decisions made regarding the enforcement of the ordinances, and order the issuance of certain types of permits. Procedures and authorities related to the boards of adjustment are set out in Minn. Stat. § 394.27.

G. Planning Commissions

The procedures for and authorities of county planning commissions are set out in Minn. Stat. § 394.30.

H. Conditional Use Permits

Conditional use permits authorities for counties are detailed in Minn. Stat. § 394.301.

I. Cooperation With Municipalities

The methods for cooperation between counties and municipalities in planning and zoning services are contained at Minn. Stat. § 394.22. They provide for municipalities to contract with counties for planning and zoning services, joint planning; and procedures for enforcement of a county's comprehensive plan.

J. Interim Zoning

Counties also have the authority to issue an interim ordinance as an emergency measure to protect the public health, safety, and general welfare as the county completes its planning and zoning procedures. Minn. Stat. § 394.34. The purpose of the temporary interim ordinance is to classify and regulate the uses of land and related matters while it proceeds with the planning process and enactment of a zoning ordinance or amendment. The duration of such an interim ordinance is one year from its effective date. It can be renewed for an additional year. Minn. Stat. § 394.34.

K. Enforcement

The authorities for enforcing county official controls and zoning ordinances are detailed in Minn. Stat. § 394.37. County boards are to establish enforcement provisions. Violations of the any ordinance, regulation, or official control is a misdemeanor. County attorneys are granted the authority to bring court actions to enforce. Taxpayers of the county are granted the authority to bring mandamus actions to compel performance by officials under §§ 394.21 to 394.37.

L. Restrictions on Ordinances

County zoning ordinances regulating feedlots, like township ordinances, may also be unenforceable if they are preempted by or in conflict with state law. The Minnesota Court of Appeals held that the Blue Earth County Livestock Manure Management Ordinance was not preempted by state law or in conflict with state law. *Blue Earth County Pork Producers, Inc. v. County of Blue Earth,* C1-96-1222 (Minn. Ct. App. Jan. 28, 1997). The court found that both the statute granting MPCA the authority to issue feedlot permits and the MPCA feedlot rules contemplate a joint state and county feedlot permitting program. Because the state law contemplates a joint county and state feedlot permitting program, the court held that the county's ordinance was not preempted by state law. In addition, the court held that there was no conflict between the county ordinance and state laws even though the ordinance imposes requirements stricter than and in addition to the MPCA feedlot rules.

VII. Public Health Nuisances

(Minn. Stat. §§ 145A.01, *et seq.*)

Local public health boards may have the power to restrict operation of animal feeding operations or agricultural commodity processing facilities if they pose a serious threat to public health. The Local Public Health Act is at Minn. Stat. § 145A.02, *et seq.* Under this Act, city and county governing boards are required to undertake the responsibilities of a health board in some manner. They can do this by taking on the responsibility directly, establishing a health board, or cooperating with a joint powers board or a already operating community health board. Minn. Stat. § 145A.03, subd. 1. A board of health may authorize a township board, city council, or county board within its jurisdiction to establish a board of health and delegate by agreement powers and duties. Minn. Stat. § 145A.07, subd. 2.

One of the powers of the public health boards is to remove and abate public health nuisances. Minn. Stat. § 145A.04, subd. 8. "'Public health nuisance' means any activity or failure to act that adversely affects public health." *Id.* With regard to public health nuisances, the law provides: "If a threat to the public health such as a public health nuisance, source of filth, or cause of sickness is found on a property, the board of health or its agency shall order the owner or occupant of the property to remove or abate the threat within a time specified n the notice but no longer than 10 days." *Id.* Procedures for such notice are spelled out in this subdivision 8. Boards of health may also seek an order in court enjoining "as a public health nuisance any activity or failure to act that adversely affects the public health." *Id.*

County boards may adopt ordinances to define public health nuisances and to provide for their prevention and abatement. Minn. Stat. § 145A.05, subd. 7.

The Minnesota Commissioner of Health has the authority to appoint a board in the absence of existing board of health until one is established by the city or county governing body. Minn. Stat. § 145A.06, subd. 2.

VIII. Minnesota Corporate Farm Law

(Minn. Stat. § 500.24)

The Minnesota Corporate Farm Law places restrictions on the types of business entities that may own agricultural land or farm in this state. See Minn. Stat. § 500.24. This law affects animal agriculture by restricting the types of business entities that may either (1) own agricultural land used to raise livestock, or (2) produce livestock. While there are no court decisions addressing this issue, some have argued that the law should also be interpreted to prohibit the types of business entities that are prohibited from farming in the state also from owning livestock and raising it under a production contract.

A. Purpose of Law

The Minnesota Corporate Farm Law includes an explicit statement of purpose:

> The legislature finds that it is in the interest of the state to encourage and protect the family farm as a basic economic unit, to insure it as the most socially desirable mode of agricultural production, and to enhance and promote the stability and well-being of rural society in Minnesota and the nuclear family.

Minn. Stat. § 500.24, subd. 1.

B. Prohibitions on Ownership of Agricultural Land and on Farming

In order to meet the express purposes of the law, the Act prohibits farming by any corporation, limited liability company, pension or investment fund, or limited partnership unless the business entity meets specified definitions or exemptions. The law also prohibits corporations, limited liability companies, pension or investment funds, or limited partnerships from directly or indirectly owning, acquiring, or otherwise obtaining any interest in agricultural land other than a bona fide encumbrances taken for purposes of security on credit extended, unless the business entity meets specified definitions or exemptions. Minn. Stat. § 500.24, subd. 3.

C. Definition of Farming

The corporate farm law contains a definition of "farming" to clarify the activities that the restricted business entities are prohibited from engaging in. That definition states:

> "Farming" means the production of (1) agricultural products; (2) *livestock and livestock products;* (3) *milk and milk products;* or (4) fruit and horticultural products. It does not include the processing, refining, or packaging of said producers, nor the provision of spaying or harvesting services by a processor or distributor of farm products. *It does not include* the production of timber or forest products, *the production of poultry or poultry products, or the feeding and caring of livestock that are delivered to a corporation for slaughter or processing for up to 20 days before slaughter or processing.*

Minn. Stat. § 500.24, subd. 2(a) (emphasis added). Some argue that the "farming" definition's phrase "production of . . . (2) livestock and livestock products" may be interpreted to include ownership of livestock that is raised through a production contract. The argument is that an owner of the livestock is *producing* that livestock whether with his own labor, employee labor, or contract labor. No court has yet addressed this issue. If this farming definition is ever enforced this way, it would mean that business entities that are prohibited from directly raising livestock would also be prohibited from owning livestock and raising it through production contracts with others.

D. Definition of Agricultural Land

The corporate farm law includes a definition of agricultural land to clarify the types of property that restricted business entities are prohibited from holding an interest in:

> "Agricultural land" means real estate used for farming or capable of being used for farming in this state.

Minn. Stat. § 500.24, subd. 2(f).

E. Exemptions From Prohibitions

There are many exceptions to the corporate farm law's general prohibition against corporations, limited liability companies, pension or investment funds, or limited partnerships holding interests in agricultural land and farming. These exceptions or exemptions from the general prohibitions are detailed at Minn. Stat. § 500.24, subd. 2, paragraphs (b) through (e), (i), (j), and (m) through (v). Several of these exemptions are likely to effect animal agriculture.

1. Business Entity Exemptions

For example, business entities that meet the law's criteria for a family farm (subd. 2(b)), a family farm corporation (subd. 2(c)), an authorized farm corporation (subd. 2(d)), an authorized livestock farm corporation (subd. 2(e)), a family farm partnership (subd. 2(i)), or an authorized farm partnership (subd. 2(j)) are not prohibited from holding an interest in agricultural land or from farming. The definitions of these types of entities include detailed criteria. Some of the key principals incorporated into the definitions of these exempt business entities include:

1. That a family farm is an unincorporated farming unit owned by one or more persons residing on or actively engaged in farming.

2. That a family farm corporation is a corporation founded for the purpose of farming or owning agricultural land in which the majority of the voting stock is held by persons or spouses who are related, and at least one of the related persons is residing on or actively operating the farm.

3. That an authorized farm corporation or an authorized farm partnership allows up to five persons who are not related to each other to form business entities that will own agricultural land or farm as long as the entity meets the other specific restrictions in the definition.

4. That an authorized livestock corporation and an authorized livestock partnership allows an unlimited number of persons and family farm corporations to band together to form an entity that produces livestock other than dairy cattle, as long as 75 percent of the control and financial and capital investment in the entity is controlled by farmers residing in Minnesota and 51 percent of that percentage are actively engaged in farming and the other specific restrictions are met.

2. Research and Breeding Stock Exemptions

The law also provides exemptions from the general prohibitions against holding interests in agricultural land and farming for certain "research and experimental farms" (subd. 2(m)) and for "breeding stock farms" (subd. 2(n)). These definitions are as follows:

> "Research or experimental farm" means a corporation, limited partnership, or pension or investment fund that owns or operate agricultural land for research or experimental purposes, provided that any commercial sales from the operation are incidental to the research or experimental objectives of the corporation. a corporation, limited partnership, or pension or investment fund seeking initial approval by the commissioner to operate agricultural land fore research or experimental purposes must first submit to the commissioner a prospectus or proposal of the intended method of operation containing information required by the commissioner including a copy of any operational contract with individual participants. (Minn. Stat. § 500.24, subd. 2(m)).
>
> 'Breeding stock farm" means a corporation or limited partnership that owns land for the purpose of raising breeding stock, including embryos, for resale to farmers or for the purpose of growing seed, wild rice, nursery plants, or sod. An entity that is organized to raise livestock other than dairy cattle under this paragraph that does not qualify as an authorized farm corporation must:
>
> (1) sell all castrated animals to be fed out or finished to farming operations that are neither directly nor indirectly owned by the business entity operating the breeding stock operation; and
>
> (2) report its total production and sales annually to the commissioner. (Minn. Stat. § 500.24, subd. 2(n)).

3. Exemption for Property Acquired Through Enforcement of Liens

The corporate farm law also provides exemptions from the general prohibitions against holding interests in agricultural land and farming for corporations, limited partnerships, or pension and investment funds that acquire land or livestock through enforcement of a lien or claim on that property. Agricultural land so acquired must be disposed of within five years. During this five years, it may not be used for farming unless it is under a lease to a family farm unit, a family farm corporation, an authorized farm corporation, an authorized livestock farm corporation, a family farm partnership, or an authorized farm partnership. If the land is leased to the immediately previous owner, the acquiring business entity may hold the land for ten years. Livestock that is acquired by a corporation, limited partnership, or pension or investment fund which through collection or a debt or enforcement of a lien or claim on the livestock must divest of that livestock within one production cycle for that type of livestock or 18 months, whichever is later.

F. Reports to Commissioner

The corporate farm law requires that business entities seeking to avail themselves of the exemptions to the prohibitions against holding interests in agricultural land or farming must provide detailed reports to the Minnesota Commissioner of Agriculture. The report requirements are found at Minn. Stat. § 500.24, subd. 4.

G. Enforcement

The corporate farm law provides for enforcement of its provisions by the Minnesota Attorney General's office through lawsuit in district court. Minn. Stat. § 500.24, subd. 5.

IX. Nuisance Law

(Minn. Stat. §§ 561.01, *et seq.*)

In some instances operations producing or processing livestock or poultry may be sued for nuisance theories of law. Minnesota nuisance statutes are found at Minn. Stat. § 561.

A. Definition of a Nuisances

Minnesota Statutes define a nuisance as "anything which is injurious to health, or indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property." Minn. Stat. § 561.01.

B. Remedies for Nuisance

Any person whose property is injuriously affected or whose personal enjoyment is lessened by the nuisance may bring an action in court to obtain an order enjoining the nuisance, to abate the nuisance, and/or for money damages. See Minn. Stat. § 561.01.

C. Trespass of Animals

Farm animals that trespass on others' land may be impounded. Minn. Stat. § 561.07. The owner of animals that do damage to others property may be held liable for such damages. Minn. Stat. § 561.09.

D. Nuisance Liability Limits for Agricultural Operations (Right to Farm Law)

Minnesota law provides that agricultural operations that meet specific criteria are not nuisances. See Minn. Stat. § 561.19. Minnesota law states:

> An agricultural operation is not and shall not become a private or public nuisance after two years from its established date of operation if the operation was not a nuisance at the established date of operation.

Minn. Stat. § 561.09, subd. 2(a). In addition, for purposes of nuisance litigation, "an agricultural operation is operating according to generally accepted agricultural practices if it is located in an agriculturally zoned area and complies with the provisions of all applicable federal and state statutes and rules or any issued permits for the operation." Minn. Stat. § 561.19, subd. 2(b). However, the provisions of subdivision 2(a) and (b) do not apply in the following circumstances:

1. To a condition or injury which results from the negligent or improper operation of an agricultural operation or from operations contrary to commonly accepted agricultural practices or the applicable state or local laws, ordinances, rules, or permits;

2. When an agricultural operation causes injury or direct threat of injury to the health or safety of any person;

3. To the pollution of, or change in the condition of, the waters of the state or the overflow of waters on the lands of any person;

4. To an animal feedlot facility with a swine capacity of 1,000 or more animal units as defined in the rules of the pollution control agency for control of pollution from animal feedlots, or a cattle capacity of 2,500 animals or more; or

5. To any prosecution for the crime of public nuisance as provided in section 609.74 or to an action by a public authority to abate a particular condition which is a public nuisance.

Minn. Stat. § 561.19, subd. 2(c).

"Agricultural operation," for purposes of these provisions, is defined at Minn. Stat. § 561.19, subd. 1(a). It includes operations producing livestock, poultry, poultry products, and dairy products, among other things. But it does not apply to operations that are primarily engaged in processing of agricultural products.

The "established date of operation" is also defined for purposes of these provisions at Minn. Stat. § 561.19, subd. 1(b). The established date of operations for operations with significant expansions, 25 percent or more, in the amount of a particular crop or type of livestock production, or a significant change in the type of crop or livestock production, will be the date the expansion or alteration commenced.

X. Producer Protection Act

(Minn. Stat. §§ 17.90, *et seq.;* Minn. R. 1572.0010, *et seq.*)

Production contracts control an ever increasing percentage of the crops, livestock, and poultry produced in this country. Production contracts are a key tool used to vertically integrate some sectors of agriculture. Through such contracts, individuals and companies who process or market livestock or crops can maintain control over production segments without owning the production facilities or land. In other instances, production contracts are used by individuals or companies to control different segments of the production cycle for livestock from breeding, to nursery, and to finishing without owning the facilities for all segments of production. Farmers, often known as contract growers, who grow livestock or poultry under production contracts typically provide facilities, labor, and utilities but do not own the animals. They are paid pursuant to the terms of the contract and do not carry the responsibility or risk of marketing the animals for slaughter.

Marketing agreements in which a producer of an agricultural commodity agrees to sell that commodity to a processor and/or marketer of the commodity are also becoming much more broadly used today.

Minnesota has a law that is designed to provide some protections for contact growers participating in production contracts and producers participating in marketing agreements. This law is commonly know as the Producer Protection Act. Minn. Stat. § 17.90, *et seq.* There are five key provisions of this law: recapture of capital investment, alternative dispute resolution, parent company liability, implied promise of good faith, and licensure. (The following discussion contains excerpts from: Roth, Randi, "Breeding Change—Legislative Remedies for Contract Growers, Part 1: Minnesota State Law," *Farmers' Legal Action Report,* Vol. 7 No. 4 (Autumn 1992).

A. Application of Statute

The statute applies to "producers" of "agricultural commodities." These terms are defined in the statute. Minn. Stat. § 17.90, subds. 2 and. 4. Agricultural commodities include, among other things, livestock, livestock products, poultry, poultry products and materials produced for use in food, feed, seed or fiber. Minn. Stat. § 17.90, subd. 2. "'Producer' means a person who produces or causes to be produced an agricultural commodity in a quantity beyond the person's own family use and is able to transfer title to another or provides management, labor, machinery, facilities, or any other production input for the production of an agricultural commodity." Minn. Stat. § 17.90, subd. 4. Another key term, "contractor," is also defined in the statute: "'contractor' means a person who in the ordinary course of business buys agricultural commodities grown or raised in this state or who contracts with a producer to grow or raise agricultural commodities in the state." Minn. Stat. § 17.90, subd. 3.

B. Recapture of Capital Investment

Growers often must make significant capital investments in facilities, equipment and land in order to obtain a production contract. Such investments can be very risky for the grower if he or she can only secure a short-term contract. The "recapture of capital investment" provision of the Minnesota law is designed to offer some protection to growers who are in these situations.

1. The Statute

There are two parts to the statute. Minn. Stat. § 17.92. The first part provides that a company must not terminate or cancel a contract that requires a grower to make a capital investment in a building or equipment that costs $100,000 or more and has a useful life of at least five years until certain conditions are met. Minn. Stat. § 17.92, subd. 1. The conditions are:

1. The company must have given the grower *written* notice of its intent to terminate or cancel at least 180 days before the effective date of the termination or cancellation; and

2. The grower must have been reimbursed for the damages that he or she incurred by making such an investment. (The investment must have been made for the purpose of meeting the minimum requirements of the contract.) Minn. Stat. § 17.92, subd. 1(2).

The second part of the statute addresses situations in which the company complains that termination is necessary because the grower has breached the contract. The statute provides that if the contract required a capital investment, the company cannot terminate or cancel a grower who has breached the contract until:

1. The company has given the grower a *written* notice that lists all of the reasons for the termination or cancellation at least 90 days before the termination or cancellation; and

2. The grower fails to correct the reasons stated in the notice within 60 days of receipt of the notice. Minn. Stat. Sect 17.92, subd. 2.

There are exceptions to these grower protections in certain extreme situations. The requirements for the 180-day and 90-day notice periods described above are waived and the contract may be terminated or canceled immediately if the alleged grounds for termination or cancellation are either: (1) voluntary abandonment of the contract relationship by the grower; or (2) conviction of the grower for an offense directly related to the business conducted under the contract. Minn. Stat. § 17.92, subd. 3.

2. The Rules

The rules interpret the statute in a manner that may be seen by growers to weaken their protections in three significant ways. See Minn. R. 1572.0030.

First, the statute applies only to situations in which the company *requires* the grower to make a capital investment. The rules clarify the meaning of the word "requires" by providing that the grower must have a "*written* contractual obligation" to make the improvement. Minn. R. § 1572.0030, subp. 1 (emphasis added). This means that when companies use *oral* statements to communicate to growers that they are required to make improvements, the growers are not protected by the law.

Second, the statute applies to "termination" and "cancellation" of a contract. Before the rules were promulgated, many interested parties thought that the terms "termination" and "cancellation" were meant to apply to two different situations. It was assumed that one term applied to situations in which a company ends a growing arrangement while a contract is still in effect, and that the other term applied to situations in which a company decides *not to renew* a short contract that expired (for example, a contract that covers only one flock). The rules did not interpret the statute in that way. The rules provide that "'[t]ermination' and 'cancellation' do not include *expiration* of the contract." Minn. R. 1572.0030, subp. 17 (emphasis added).

Third, the statute did not explain how "damages" are to be computed. The rules explain that damages "do not include payment for the reasonable useful life of an asset that extends beyond the term of the contract." Minn. R. 1572.0030, subp. 1. This seems to mean that the grower can recover the profit that he or she could have expected to make from the investment during the duration of the contract. It is unclear whether this rule would be interpreted to imply that a grower cannot recover out-of-pocket expenses as part of his or her damages.

C. Alternative Dispute Resolution

The Producer Protection Act also requires that contacts provide certain types of forums for resolution of conflicts between the parties to production contracts and marketing agreements.

1. The Statute

The statute provides that every contract "must contain language providing for resolution of contract disputes by either mediation or arbitration." Minn. Stat. § 17.91.

2. The Rules

The rules simply lay out the details of how the mediation or arbitration arrangements shall be made. Minn. R. 1572.0020 and 1572.0010, subps. 2 and 5. The rules provide that this alternative dispute resolution law applies only to contracts signed after August 1, 1990.

D. Parent Company Liability

Sometimes the company that contracts with a contract grower or producer is a small company that is a subsidiary of a larger company. The Minnesota State Task Force that studied problems with contract farming concluded that in some cases the smaller companies failed to pay the growers and became bankrupt, leaving the growers with no recourse. (Agricultural Contracts Task Force, Final Report to the 1990 Legislature (Feb. 1990), Minnesota Department of Agriculture (90 West Plato Boulevard, St. Paul, Minnesota, 55107), pp. 1 and 3.) This statute is designed to make it possible for growers in this situation to recover from the parent company.

1. The Statute

The statute simply says that if the contracting company is:

> [T]he subsidiary of another corporation, partnership, or association, the parent corporation, partnership, or association is liable to a seller for the amount of any unpaid claim or contract performance claim if the contractor fails to perform according to the terms of the contract. Minn. Stat., § 17.93.

The statute also provides that if the company is required to be licensed to purchase agricultural commodities, the licensing authority may require the parent company to guarantee payment or contract performance as a condition of licensing.

The statute does not define "subsidiary" or "parent company."

2. The Rules

The rules define parent company as an entity that owns more than 50 percent of the common or preferred stock entitled to vote for directors of a subsidiary corporation or provides more than 50 percent of the management or control of a subsidiary. Minn. R. 1572.0040. The entity must be a corporation, partnership, sole proprietorship, or association. This "ownership" can be through ownership of capital stock, cumulative voting rights, voting trust agreements, or any other plan, agreement, or device.

E. Implied Promise of Good Faith

A party to a production and marketing contract sometimes takes actions for its own benefit but at the expense of the other party. In some instances the actions are acceptable within the business relationship, but in other instances the actions constitute bad faith. Before the passage of this law, if one party to the contract took action in bad faith that caused harm to the other party but the action was technically within the letter of the law, the other party had no recourse.

1. The Statute

The statute provides that there is an implied promise of good faith by all parties in all agricultural contracts. It states that in an action to recover damages for a breach of this promise of good faith, damages, court costs, and attorney fees may be recovered. The definition of "good faith" is "honesty in fact in the conduct or transaction concerned." Minn. Stat. § 17.94. "Good faith" is defined at Minn. Stat. § 336.1-201, subs. (19).

2. The Rules

There are no rules interpreting this part of the statute.

F. Prohibition of Confidentiality Provisions

As production contracts and marketing agreements become more widely used in animal agriculture many producers have become concerned that they will not have access to sufficient information about prices paid for livestock because many contracts include provisions prohibiting the parties to the contract from disclosing price and purchase term information. In 1999, the state legislature enacted a statutory provision that prohibit confidentiality clauses in contracts. Minn. Stat. § 17.710. This provision states:

> A production contract entered into, renewed, or amended on or after July 1, 1999, between an agricultural producer and a processor of agricultural products must not contain provisions that prohibit the producer from disclosing terms, conditions, and prices contained in the contract. Any provision prohibiting disclosure by the producer is void.

Minn. Stat. § 17.710.

XI. Wholesale Produce Dealers Act

(Minn. Stat. §§ 27.001, *et seq.;* Minn. R. 1500.1401 (or 1500.100, *et seq.*))

The Minnesota Wholesale Produce Dealers Act provides licensure requirements for wholesale produce dealers and financial protections for producers of some perishable agricultural commodities. Minn. Stat. §§ 27.001, *et seq.*

A. Produce Covered

The types of produce covered by the Act include: (1) perishable fruits and vegetables, (2) milk and cream and products manufactured from milk and cream; and (3) poultry and poultry products. Minn. Stat. § 27.001, subd. 2.

B. Licensure and Bonding Requirements

The Wholesale Produce Dealers Act requires that all produce dealers must be licensed. Minn. Stat. § 27.03. The definition of "wholesale produce dealer" is at Minn. Stat. § 27.01, subd. 8. Generally, this definition includes persons who buy or contract to buy produce, brokers or agencies handling deals for produce, and processors of produce. Application procedures of licenses are at Minn. Stat. § 27.04. It is significant that the companies must be licensed, because companies are in danger of losing their licenses if they commit any one of several violations of the act. See Minn. Stat. § 27.19.

C. Provisions Similar to Producer Protection Act

The Wholesale Produce Dealers Act also includes provisions regarding mediation and arbitration clauses in contracts and parent company liability similar to those contained in the Producer Protection Act discussed above. Minn. Stat. §§ 21.131 and 27.133.

D. Protections for Sellers (Producers)

Wholesale produce dealers are also required to be bonded. The bonds are conditioned on the faithful performance of all duties of a wholesale produce dealer under the law including prompt payment to producers. See Minn. Stat. § 27.041, subd. 1. Persons claiming a violation of the condition of a bond, such as a failure to pay a producer seller when due, may file complaints with the Minnesota Commissioner of Agriculture. Minn. Stat. § 27.06.

In addition to making a claim against a wholesale produce dealer's bond for the dealer's failure to pay when due, sellers or producers may also make claims on the dealer's trust assets. The law requires that all produce and products of produce of a wholesale produce dealer be held in trust for the benefit of the unpaid sellers. Minn. Stat. § 27.138. A producer seller may recover trust assets after filing a beneficiaries notice through a complaint to the Commissioner of Agriculture or through a filing in district court.

The Act also prohibits many other actions by wholesale produce dealers. These prohibited actions include such things as making of false statements; violation of the terms of a contract; the failure to make payment in full for all produce committed for; issuing misleading market quotations; making a false statement or report on grade, conditions, markings, quality or quantity of produce; failure to notify in writing all suppliers of the license bond availability; discriminating between different sections, localities, communities, or cities, or between persons in the same community by purchasing produce from farmers of the same grade, quality, and kind, at different prices, except if price differentials are based cost of transportation, shipping, and handling of the produce or to meet a competitors price. Minn. Stat. § 27.19.

The Commissioner of Agriculture is in charge of enforcing the provisions of the Wholesale Produce Dealers Act. The Act provides for civil penalties and upon conviction in court, criminal misdemeanor penalties.

E. The Rules

The rules implementing the Wholesale Produce Dealers Act are located at Minn. R. 1500.1401. The rules provide a list of prohibited actions that provide strong protection for sellers of "produce" as defined by the Act. Minn. Stat. Sect 27.19. The rules contain a list of "unfair trade practices." If a company commits any of the unfair practices on the list, the company is in danger of losing its license and forfeiting its bond and in some cases trust assets. The list includes, among other things:

1. Making a false or misleading statement for a fraudulent purpose, including statements made to induce a person to sign a contract (Minn. R. 1500.1401(A)); and

2. Using coercion, intimidation, the threat of retaliation, or the threat of contract termination to impose, demand, compel, or dictate the terms, payment or manner of payment, or the signing of a contract by a producer (Minn. R. § 1500.1401(D)).

XII. Agricultural Marketing and Bargaining Act

(Minn. Stat. §§ 17.691, *et seq.*)

Minnesota's Agricultural Marketing and Bargaining Act, Minn. Stat. §§ 17.691, *et seq.,* is designed to ensure that farmers, ranchers, and handlers are free to join together voluntarily into cooperative associations that will bargain for and market agricultural commodities. Under this law, milk producers, poultry growers, or livestock producers could join together in an association to market and bargain for sales of their animals and animal products. The Act's stated purpose is to establish standards of fair practices required by handlers and producers in their marketing and bargaining dealings in agricultural products and to encourage settlement of disputes between handlers and producers. Minn. Stat. § 17.692.

A. Marketing and Bargaining Association

This law establishes a procedure by which an association of producers that intends to bargain for the sale of the agricultural commodities of its members can obtain accreditation from the Commissioner of Agriculture to be the official bargaining agent for producers in the bargaining unit area identified. Once accredited, the association establishes a bargaining committee that will be association's exclusive agent to negotiate with handlers for the sale and marketing of the agricultural commodity. Minn. Stat. § 17.695.

B. Bargaining Procedures, Mediation, and Arbitration

The law also sets out procedures to be followed for negotiation between the association and handlers regarding terms and conditions of trade of agricultural commodities. Minn. Stat. § 17.697. These procedures include informational exchanges between handlers and the bargaining association, mediation, and binding arbitration. Factors to be considered in mediation and arbitration of disputes are outlined at Minn. Stat. § 17.698.

C. Unfair Practices

Unfair practices of handlers and associations are detailed at Minn. Stat. § 17.696. Handlers are prohibited from engaging practices such as coercing producers not to join an association; discriminating against producers with respect to price, quantity, quality, or other terms of purchase of agricultural commodities due to membership or contract with an association; paying anything of value to producers to induce them to refuse of cease to belong to an association; circulating unsubstantiated reports about the finances or management of the association; etc. Minn. Stat. § 17.696, subd. 1. Similarly, associations are prohibited from engaging in unfair practices such as coercing a producer to join an association; entering into a contract that discriminates against a producer represented by that association; coercing a handler from breaching or canceling a contract with an association or a producer; circulating unsubstantiated reports about finances or management of associations or handlers; etc. Minn. Stat. § 17.696.

D. Enforcement

The Commissioner of Agriculture may receive and investigate complaints of violations of this Act. Procedures for administrative hearing on alleged violations made by the Commissioner are outlined at Minn. Stat. § 17.70. As a result of such hearing, a violating party may be ordered to cease the violation and order other affirmative actions to effectuate the policies of the Act. The Commissioner may also request that the attorney general seek injunctive relief from a district court. *Id.*

XIII. Minnesota Packers and Stockyards Act

(Minn. Stat. §§ 31B.01, *et seq.*)

The Minnesota Packers and Stockyards Act regulates some activities of livestock packers, stockyards, livestock marketing agencies, and dealers. Minn. Stat. §§ 31B.02-.06.

A. Reporting Requirements

Packers, stockyard owners, market agencies, dealers and grain and feed businesses with livestock contracts are required to file with the Minnesota Commissioner of Agriculture a copy of the annual report required by the federal Packers and Stockyards Administration and any additional information required by the Commissioner. Packers must also file annually the maximum capacity of each of the packer's packing plants and copies of each contract entered into with a livestock producer for the purchase of or contracting of livestock. Minn. Stat. § 31B.03.

B. Prompt Payment for the Purchase of Livestock

The Minnesota Packers and Stockyards Act requires that packers promptly pay for the purchase of livestock. Packers, marketing agencies, or dealers purchasing livestock must pay the seller or the seller's representative the full amount of the purchase price by the next business day following purchase of the livestock and transfer of its possession. For purchases of livestock for slaughter on a carcass or grade and yield basis, payment must be made to the seller by the end of the business day following determination of the purchase price. However, the law does allow that the parties may agree in writing to other terms for effecting payment, so long as they comply with rules passed by the Commissioner and are reflected in the records of the market agency, dealer, and/or purchaser. Delays or attempts to delay payment for livestock beyond the normal period for payment is and "unfair practice" in violation of the Act. Minn. Stat. § 31B.04.

C. Penalty for Packer Failure to Fulfill Contract to Purchase Livestock

Packers are subject to suspension or revocation of their license if they commit orally or in writing to buy more livestock than the packer's plant can process and cannot fulfill the commitment to the producer within 30 days of the delivery date in the contract. Minn. Stat. § 31B.05.

D. Accounting Requirements for Contract Livestock Feeding

Hog, cattle, sheep, and dairy processors with annual sales greater than $10 million are required to conduct all financial transactions for contract livestock feeding operations through a separate and exclusive bank account. This back account is subject to audit and inspection by the Commissioner of Agriculture. Grain and feed businesses with annual sales greater than $10 million must also meet these requirements for contract feeding of hogs, cattle, sheep, or dairy cows. Minn. Stat. 31B.06.

XIV. Livestock Price and Contract Reporting
(Minn. Stat. § 31B.07)

Many livestock producers have been complaining that there is not sufficient information reported publicly regarding prices and terms of purchase of livestock to allow them to make informed decisions about marketing their animals for slaughter. In 1999, the Minnesota Legislature enacted mandatory price reporting laws for livestock packers. The new statutory provisions require both a daily report and quarterly reports. Minn. Stat. § 31B.07.

A. Daily Reports

Packers must report daily detailed price and purchase term information to USDA's Agricultural Marketing Service and to Minnesota's commissioner of agriculture. At the close of each business day packers must report all prices paid for livestock under contract and through cash market sales during that business day. Minn. Stat. § 31B.07, subd. 1. These reports must include:

> (1) the amount of the base price and a description of the formula used to establish that base price;
>
> (2) a description of the types and amount of any premiums or discounts including but not limited to quality characteristics, grade and yield, volume, early delivery, percent lean, and transportation or acquisition cost savings to the packer; and
>
> (3) the base on which payment was made including live-weight, carcass weight, or value in the meat.

Minn. Stat. § 31B.07, subd. 1(a).

The commissioner of agriculture is required to make the information reported in the packers' daily reports available to the public, through electronic means, on the day succeeding the day covered by the reports. Minn. Stat. § 31B.07(a)(3). The statute prohibits publication of report information in a form that would identify the parties to the transactions, identify the packer submitting the report, or describe propriety information. Minn. Stat. § 31B.07, subd. 1(b).

B. Quarterly Reports

Packers are also required to file quarterly reports with the commissioner of agriculture within 10 days of the close of each calendar quarter. Minn. Stat. § 31B.07, subd. 2. The quarterly report must include "copies of each type of marketing agreement, contract, and joint venture agreement used by the packer to procure slaughter livestock from producers during the previous calendar quarter." Minn. Stat. § 31B.07, subd. 2(a). The commissioner must publish a summary report of the contract terms and prices offered by packers during the previous calendar quarter, within 15 days of receipt of the quarterly reports. Minn. Stat. § 31B.07, subd. 2(b).

C. Termination of Reporting Requirements

If the federal government develops a price reporting program for packers that "is at least as comprehensive" as the state provisions, the state reporting requirements will end within 30 days. Minn. Stat. § 31B.07, subd. 3.

D. Legislation and Litigation in Other States

During the 1999 legislative sessions, South Dakota, Nebraska, and Missouri passed laws similar to Minnesota's law requiring packers to report details about prices and contract terms for slaughter livestock purchases. In addition to the price reporting provisions, these other states' Acts also attempted to prohibit discrimination among producers in prices paid for slaughter livestock. The South Dakota Act was challenged in the United States District Court for the District of South Dakota. On July 26, 1999, the court issued a decision holding that the provisions of the Act prohibiting discrimination in prices paid among producers was unconstitutional because it violated the Dormant Commerce Clause by affecting interstate commerce. All reporting provisions tied to the prohibition against discrimination in pricing were also struck down as unconstitutional. However, provisions exclusively involving price and contract term reporting were upheld. See *American Meat Institute and John Morrell & Company v. Barnett,* Civ. 99-0317 (Dist. of S.D., July 26, 1999).

E. Federal Mandatory Price Reporting

In response to pressures created by several states which passed laws mandating that packers report details of prices and contract terms for purchases of slaughter livestock, Congress is considering bills that would establish national mandatory price reporting standards. The political climate is such that it is likely that Congress will pass some form of mandatory price reporting legislation within the next year. Just before Congress's August 1999 recess, the Senate Committee on Agriculture, Nutrition, and Forestry reported out a mandatory price reporting bill. This bill has gone the furthest in the legislative process. It provides for detailed mandatory price reporting for beef, hog, and sheep slaughter. The provisions are different for the different species.

XV. Agricultural Production Contract Study and Report

In 1999, the state legislature mandated that the commissioner of agriculture study the "current and projected impacts of increasing amounts of livestock, poultry, and specialty crops produced under contracts with processors, and the effect of contract production on access to competitive markets for producers who choose not to produce under contract." Section 205(a) of Act of May 25, 1999, Chapter 231, 1999 Minn. Sess. Laws, Section 205. By February 15, 2000, the commissioner is required to report findings of the study, including any recommendations for changes in laws, to the agriculture committees of the Minnesota House and Senate. *Id.*

XVI. Prohibition Against Price Discrimination in Purchase of Farm Products (Minn. Stat. §§ 17.14, *et seq.*)

Under Minnesota law it is unlawful for any person engaged in the business of buying farm products to discriminate between different sections, localities, communities, or cities, or between persons in the same community, in this state, by purchasing farm products at a higher price or rate in one locality or from one person who is paid for farm products of the same kind, quality, and grade purchased from another person or locality, unless the price differentials meet specified criteria. Paying different prices is not unlawful discrimination if the differential in price reflects reasonable costs of transportation. It is also not unfair discrimination to pay a price equal to that actually paid on the same day by a bona fide competitor if such price is paid in good faith effort to meet such competition. Minn. Stat. § 17.15.

"Farm products" for purposes of this anti-discrimination in pricing provision include "butter, milk, cream, butterfat, cheese, other dairy products, honey eggs. poultry, poultry products, perishable fresh fruit and vegetable, and all livestock and products of livestock such as wool, mohair, hides, and meats." Minn. Stat. § 17.14, subd. 3.

The Commissioner of Agriculture has the authority to investigate complaints of violations of this provision. If the Commissioner believes that grounds exist, he can bring an action in court on behalf of the state to enforce this provision. A court finding a violation by a corporation can revoke the authority of the corporation to do business in this state. Minn. Stat. § 17.17. Any prosecuting officer or interested party may also bring civil or criminal proceedings to enforce the law. Minn. Stat. § 17.18.

XVII. Feedlot and Manure Management Advisory Committee (Minn. Stat. § 17.136)

The commissioners of agriculture and pollution control agencies were required to establish a feedlot and manure management advisory committee "to identify needs, goals, and suggest policies for research, monitoring, and regulatory activities regarding feedlot and manure management." Minn. Stat. § 17.136(a). The make-up of the committee is set out at Minn. Stat. § 17.136(b). The advisory committee is to be consulted by the pollution control and agriculture commissioners during the development of any policies, rules, or funding proposals or recommendations relating to feedlots or manure management and on establishing a list of manure management research needs and priorities. Minn. Stat. §§ 17.136(d) and (e); see also Minn. Stat. § 17.138, subd. 1. In consultation with the advisory committee, the commissioners of agriculture and pollution control are also required to develop voluntary best management practices for odor control of feedlots. Minn. Stat. § 17.138, subd. 3.

XVIII. Sustainable Agriculture

(Minn. Stat. § 17.114)

Sustainable agriculture programs will also impact the development of animal agriculture in the state. Pursuant to Minnesota Statute § 17.114, the commissioner of agriculture is required to "investigate, demonstrate, report on, and make recommendations on the current and future sustainability of agriculture in this state." For purposes of this section of the law "sustainable agriculture" is defined as representing "the best aspects of traditional and modern agriculture by using a fundamental understanding of nature as well as the latest scientific advances to create integrated, self-reliant, resource conserving practices that enhance the enrichment of the environment and provide short- and long-term productive and economical agriculture." Minn. Stat. § 17.114, subd. 2(a).

The commissioners duties include: (1) establishing a clearinghouse and providing information educational opportunities, and other assistance about sustainable agricultural techniques, practices and opportunities; (2) surveying producers and organizations to determine information and research needs on sustainable techniques; (3) demonstrating the on-farm application of sustainable practices; coordinate state agencies efforts on sustainable agriculture; (4) directing the programs of the department so as to work toward sustainability of agriculture in the state; (5) information agencies of how state or federal program could utilize and support sustainable agricultural practices; (6) working with farmers, University of Minnesota and other organizations to identify opportunities and assure coordination and avoid duplication of state agency efforts regarding research, teaching and extension work on sustainable agriculture; and (7) reporting to the environmental quality board (EQB) and the legislative water commission every even-numbered year. Minn. Stat. § 17.114, subd. 3(a).

The report to the EQB and the legislative water commission are spelled out at Minn. Stat. § 17.114, subd. 3(b).

The commissioner of agriculture is also required to establish a sustainable agriculture advisory committee to assist him in carrying out his duties. "The committee must include farmers, higher education representatives with expertise in sustainable agriculture, officials from other state agencies, representatives from the agricultural utilization research institute, private sector agricultural professionals, and representatives from environmental and agricultural interest groups." Minn. Stat. § 17.114, subd. 3a.

XIX. Market Champ
(Minn. Stat. § 17.987)

Market Champ, Inc. was established as a nonprofit public corporation under Minn. Stat. 317A for the purpose of transferring high quality genetic material from the University of Minnesota to family farmers of the state to enhance the state's economic growth and competitiveness of family farmers. Minn. R. 17.987, subd. 1. Market Champ is neither a state agency nor an entity within the university of Minnesota.

The duties of Market Champ, Inc. are to:

(1) encourage family farmers to use the highest quality swine genetics;

(2) facilitate the transfer of the latest swine genetic research and technology information and materials from the University of Minnesota and other sources to family farmers;

(3) assist family farmers to market the swine they produce;

(4) develop a system for tracking family farmers' products through the processing, meat packing, and marketing system to determine the market value of the genetic technology;

(5) provide genetic testing, counseling, and assistance in genetic decisions to identify new market developments and capture value-added opportunities;

(6) provide centralized testing services with regional technology transfer specialists;

(7) secure access to new genetic tests and services for all Minnesota producers through licensing agreements; and

(8) assist family farmers who do not otherwise have access to high quality genetic technologies.

Minn. Stat. § 17.987, subd. 2.

The make-up of the board of directors is described at Minn. Stat. § 17.987, subd. 3. Bylaw, article of incorporation, audit, and report requirements are contained in subds. 4, 5, 6, and 7, respectively. Subdivision 8 provides that the board of directors of Market Champ, Inc. expires on June 30, 2003.

XX. Loan Programs

(Minn. Stat. § 17.117)

There are several state programs to loan money to farmers that impact the availability of credit for animal agriculture operations. Some examples of these loan programs are described below.

A. Agriculture Best Management Practices Loan Program

(Minn. Stat. § 17.117)

The purpose of the Agriculture Best Management Practices Loan Program "is to provide low or no interest financing to farmers, agriculture supply businesses, and rural landowners for the implementation of agricultural best management practices." Minn. Stat. 17.117, subd. 1. This program requires the commissioner of agriculture to implement a program " to make loans to local units of government, federal authorities, lending institutions, and other appropriate organizations who will in turn provide loans to landowners and businesses for facilities, fixtures, equipment, or other sustainable practices that prevent or mitigate sources of nonpoint source water pollution." Minn. Stat. § 17.117, subd. 2. Details of the authorized program are spelled out at Minn. Stat. § 17.117, subds. 1-17.

B. Shared Savings Loan Program

(Minn. Stat. § 17.115)

Minn. Stat. § 17.115 establishes the shared savings loan program "to provide loans that enable farmers to adopt best management practices that emphasize sufficiency and self-sufficiency in agricultural inputs, including energy efficiency, reduction in petroleum and chemical inputs, and increasing energy self-sufficiency of agricultural producers. Minn. Stat § 17.115, subd. 1. The loan must provide for purchase of new or used machinery, installation of equipment, and projects that reduce or make more efficient farm energy use. The loans must be made to Minnesota residents who engage in farming and may not exceed $15,000 per individual or $75,000 for loans to five or more individuals on joint projects. Minn. Stat. § 17.115, subd. 2. Procedures for awarding the loans is covered by subdivision 3.

C. Family Farm Security Loan Program

(Minn. Stat. § 41.51 *et seq.)*

The legislature established the family farm loan security program in order to aid farmers in obtaining credit for the acquisition of farm real estate. Minn. Stat. § 41.51. The family farm security program provides state money in guarantees of loans made by lenders according to this chapter.

A family farm security loan is a loan secured by a first real estate mortgage. In the case of a seller-sponsored loan, it is a loan secured either by a real estate mortgage evidenced by one or more notes or secured by a contract for deed. The loan must be used for acquisition of farmland and will be guaranteed by the state. Minn. Stat. § 41.52, subd. 5. Farmland means land capable of supporting commercial production of agricultural crops, livestock or livestock products, poultry

products, milk or dairy products, or fruit of horticultural products. Minn. Stat. § 41.52, subd. 6.

Procedures for applying for and approval of these loans are contained at Minn. Stat. § 41.56. Terms of the loans are included in Minn. Stat. § 41.57. Seller-sponsored loan authorization is at Minn. Stat. § 41.58. Sale or conveyance of the land subject to the loan is covered by Minn. Stat. § 41.59.

D. Rules for Loan and Financial Assistance Programs

State rules relating to various loan programs that may be available for animal agriculture production, processing, and marketing are found at Minn. R. 1580 (Agricultural Loans), Minn. R. 1587 (Financial Assistance Program), Minn. R. 1589 (Small Business Development Loan Program), Minn. R. 1650 (Beginning Farmer and Agricultural Improvement Loans), Minn. R. 1651 (Rural Finance Authority Seller-Sponsored Loan Participation Program), Minn. R. 1652 (Rural Finance Authority Agricultural Business Enterprise Loans), and Minn. R. 1656 (Rural Finance Authority Value-Added Agricultural Product Loan Program).

E. Further Research Suggestion

The limited resources provided for this literature review did not allow for an exhaustive study of all state and federal loan and grant programs that may be available for livestock, dairy, and poultry producers or businesses that deal with marketing and processing of livestock, dairy, and poultry. Because access to capital is extremely important in animal agriculture and the structure of government programs that are designed to fill in the gaps of private capital sources can play a key role in encouraging certain types of animal agricultural production, processing, and marketing, we recommend that further research on grant and loan programs be conducted.

XXI. State Tax Laws

(Minn. Stat. § 272.02)

State tax laws will likely impact how animal agriculture develops in this state. One example of a state tax law that impacts animal agriculture is the provision that exempts from taxation personal and real property that is "used primarily for the abatement and control of air, water, or land pollution." Minn. Stat. § 272.02, subd. 1(9). There are restrictions on personal and real property for which such tax exemption can be claimed contained in this statutory provision. Large amounts of the capital investment in large confined animal feeding facilities is tied up in manure and litter disposal system (pits, lagoons, etc.), and would be taxable but for the pollution exemption. This tax exemption may give large confinement facilities a tax advantage that is not available to smaller facilities that pasture animals and use much less equipment to handle animal waste.

A. Need for Additional Research

Because the authors of this report are not tax experts and tax laws are very difficult to interpret, one area of additional research that we would recommend is how state and federal tax laws impact the development of animal agriculture.

XXII. Minnesota Department of Agriculture Inspection, Licensing, and Labeling Laws

(Minn. Stat. ch. 31, 31A, and 32; Minn. R. 1510, 1525, 1530, 1535, 1540, 1545, and 1555)

The Minnesota Department of Agriculture is responsible for administering and enforcing many inspection, labeling, and licensing provisions that impact animal agriculture. These programs include the Meat Inspection Program at Minn. Stat. §§ 31A.01-.31, which was amended in the 1999 legislative session to incorporate poultry into the existing meat and meat food product inspection provisions. See 1999 Session Laws, ch. 231, §§ 58-64. The meat inspection rules are found at Minn. R. 1540. Other meat and poultry industry rules are found at Minn. R. 1545. Livestock and poultry importation rules are at Minn. R. 1700.

The various statutory provisions on dairy issues administered and enforced by the Minnesota Department of Agriculture are found Minn. Stat. §§ 32.01-.75. These provisions address licensing of milk and cream testers; dairy planning, licensing, and inspection; prohibitions in discrimination by purchasers of dairy products: dairy industry records and related regulatory programs: butter and cheese standards; frozen dairy products; and restrictions on certain dairy trade practices. Minnesota Statutes § 32.21 entitled "adulterated dairy products" is the statutory provision that prohibits the sale of adulterated milk products and establishes penalties for violations of these standards. The dairy division rules of the Minnesota Department of Agriculture are found at Minn. R. 1525. The milk and milk products standards rules are at Minn. R. 1530. Rules relating to cheese and cheese products are found at Minn. R. 1535.

The various statutory provisions related to the food processing and distribution provisions are administered and enforced by the Minnesota Department of Agriculture are found at Minn. Stat. §§ 31.001-.96. The provisions of Chapter 31 that most directly relate to animal agriculture include §§ 31.53, 31.54, 31.56, and 31.58, which deal with inspection, violation, and penalty provisions for processing plants and places of business where animal and poultry slaughtering, packing, and processing are done. Minnesota Statutes § 31.101, subd. 10, was amended in the 1999 legislative session to incorporate federal regulations in effect on January 1, 1999, as provided in the Code of Federal Regulations, Title 9, part 301, *et seq.*, as part of the meat and poultry rules of the state. See 1999 Minn. Session Laws, ch. 231, § 55. This chapter of the statutes also addresses fair packaging and food labeling provisions for consumer food products at Minn. Stat. §§ 31.103, 31.104, and 31.12. The specific meat and poultry provisions of the food laws are found at Minn. Stat. § 31.60-.633. Organic food and certification provisions are found at Minn. Stat. §§ 31.92-.96. The general food rules and the food definition and standards rules are found at Minn. R. 1550 and 1555.

The Minnesota Department of Agriculture also administers and enforces commercial feed laws

which include licensing, labeling, misbranding, adulteration, prohibited acts, and inspection provisions. Minn. Stat. §§ 25.01-.47. The commercial feeds rules are at Minn. R. 1510.1930-.2220.

Federal Law

I. The Clean Water Act

(33 U.S.C. §§ 1251, *et seq.;* 40 C.F.R. § 122.1, *et seq.;* 40 C.F.R. §§ 412.10, *et seq.;* 40 C.F.R. § 123.25)

A. The Statute

The federal Clean Water Act defines a "point source" to include "concentrated animal feeding operations." 33 U.S.C. § 1362(14). The Act prohibits a point source from discharging a pollutant into waters of the United States except in compliance with, among other things, a National Pollution Discharge Elimination System (NPDES) permit. 33 U.S.C. § 1311(a).

B. The Rules

The agency administering the Clean Water Act as it applies to feedlots is the United States Environmental Protection Agency (EPA).

1. National Pollution Discharge Elimination System Permit Rules

The general rules controlling NPDES permits are at 40 C.F.R. Part 122, subpt. A. This section provides that "[t]he NPDES program requires permits for the discharge of 'pollutants' from any 'point source' into 'waters of the United States.'" 40 C.F.R. § 122.1(b). "The terms 'pollutant,' 'point source' and 'waters of the United States' are defined in § 122.2." *Id.* The "point source" definition includes "concentrated animal feeding operation." The term "pollutant" includes "biological materials" and "agricultural waste discharged into waters." "Waters of the United States" is defined very broadly and includes even interstate waters including interstate wetlands, intrastate lakes, rivers, streams (including intermittent streams), mudflats, wetlands, sloughs, prairie potholes, and wet meadows, the degradation of which could affect interstate or foreign commerce. For these purposes interstate commerce is also defined very broadly. 40 C.F.R. § 122.2.

2. Animal Feeding Operation and Concentrated Animal Feeding Operation Definitions

Section 122.23 of the EPA rules makes it clear that certain "animal feeding operations" and "concentrated animal feeding operations" are subject to the NPDES permit program.

"Animal feeding operation" means "(1) a lot or facility . . . where the following conditions are met: (i) Animals . . . have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period and (ii) Crops, vegetation forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility. (2) Two or more animal feeding operation under common ownership are considered, for the purposes of this regulations, to be a single animal feeding operation if they adjoin each other or if they use a common area or system for disposal of wastes." 40 C.F.R. § 122.23 (b)(1)

and (2).

"Concentrated animal feeding operation means an 'animal feeding operation' which meets the criteria in appendix B of this part, or which the director designates under paragraph (c) of this section." 40 C.F.R. § 122.23(b)(3). Case-by-case designations of operations as "concentrated animal feeding operations" are controlled by 40 C.F.R. § 122.23(c).

The criteria for establishing whether an operation is a concentrated animal feeding operation for purposes of the NPDES program are contained at Appendix B to 40 C.F.R. pt. 122. This appendix provides:

> Animal feeding operation is a concentrated animal feeding operation for purposes of §122.23 if either of the following criteria are met:
> (a) More than the number of animals specified in any of the following categories are confined:
> (1) 1,000 slaughter steers and heifers;
> (2) 700 mature dairy cattle (whether milked or dry cows);
> (3) 2,500 swine weighing over 55 pounds;
> (4) 500 horses;
> (5) 10,000 sheep;
> (6) 55,000 turkeys;
> (7) 100,000 laying hens or broilers when facility has unlimited continuous flow watering systems;
> (8) 30,000 laying hens or broilers when facility has liquid manure handling systems;
> (9) 5,000 ducks, or
> (10) 1,000 animal units; or
> (b) More than the following number and types of animals are confined:
> (1) 300 slaughter or feeder cattle,
> (2) 200 mature dairy cows (whether milked or dry cows),
> (3) 750 swine each weighing over 25 kilograms (approximately 55 pounds),
> (4) 150 horses
> (5) 3,000 sheep or lambs,
> (6) 16,500 turkeys,
> (7) 30,000 laying hens or broilers (if the facility has continuous overflow watering),
> (8) 9,000 laying hens or broilers (if the facility has a liquid manure handling system).
> (9) 1,500 ducks, or
> (10) 300 animal units:
> and either one of the following conditions are met: pollutants are discharged into navigable waters through a manmade ditch, flushing system or other similar man-made device; or pollutants are discharged indirectly into waters of the United

> States which originate outside of and pass over, across, or through the facility or otherwise come into direct contact with the animals confined in the operation. Provided, however, that no animal feeding operation is a concentrated animal feeding operation as defined above if such animal feeding operation discharges only in the event of a 25-year, 24-hour storm event.

40 C.F.R. pt. 122, Appendix. B. This last provision establishes an exception to the definition of a concentrated animal feeding operation for purposes of NPDES program for those operations that discharge only in a 25-year, 24-hour storm event.

3. Zero Discharge and 25-year/24-hour Rainfall Exception

The EPA rules controlling feedlots as point sources are at 40 C.F.R. pt. 412. These rules establish a zero discharge effluent limitation standard for all feedlots covered by the rules with one exception, known as the 25-year/24-hour rainfall event. 40 C.F.R. § 412.13. These rules prohibit any discharge of process waste water pollutants into navigable waters. 40 C.F.R. § 412.12(a). The 25-year/24-hour rainfall event exception to this zero discharge standard allows that "process waste pollutants in the overflow may be discharged to navigable waters whenever rainfall events, either chronic or catastrophic, cause an overflow of process waste water from a facility designed, constructed and operated to contain all process generated waster plus the runoff from a 25-year, 24-hour rainfall event for the location of this point source." 40 C.F.R. §§ 412.13(b) and 412.15(a).

4. Process Waste Water Definition

"Process waste water" under these rules means "any process generated waste water and any precipitation (rain or snow) which comes into contract with any manure, litter or bedding, or any other raw material or intermediate or final material or product use in or resulting from the production of animal or poultry or direct products (e.g. milk, eggs). 40 C.F.R. § 412.10(c). The term "process generated water" as used in these rules means "water directly or indirectly used in the operation of a feedlot for any or all of the following: spillage or overflow from animal or poultry watering systems; washing, cleaning or flushing pens, barns, manure pits or other feedlot facilities; direct contact swimming, washing, or spray cooling of animals; and dust control." 40 C.F.R. § 412.10(d).

5. Size of Feedlots Covered

These rules establishing a zero discharge effluent limitation apply to feedlots that are as large or larger than the following:

> 1,000 slaughter steers and heifers; 700 mature dairy cattle (whether milkers or dry cows); 2,500 swine weighing over 55 pounds; 10,000 sheep, 55,000 turkeys; 100,000 laying hens or broilers when facility has unlimited continuous flow watering systems; 30,000 laying hens or broilers when facility has liquid manure handling systems; 500 horses; and 1,000 animal units from a combination of slaughter steers and heifers, mature dairy cattle, swine over 55 pounds and sheep.

40 C.F.R. § 412.10. According to these rules, if any feedlot that meets these criteria discharges any pollutant into a water of the U.S. as defined by the rules, in less than a 25-year/24-hour rain event it has violated the rules implementing the Clean Water Act.

6. State Agency Implementation of NPDES Program

The procedures for EPA to approve a state program implementing the NPDES permit program are contained at 40 C.F.R. § 123.25. These rules require that for state programs to be approved by EPA they must have the legal authority to implement program consistent with EPA rules including 40 C.F.R. § 122.23 dealing with concentrated animal feeding operations. Under these rules the state approved programs need not implement provisions identical to the listed EPA program rules. Implemented provisions must, however, establish requirements at least as stringent as the listed EPA rules. States may impose more stringent requirements.

The Minnesota Pollution Control Agency has been authorized by EPA to implement the NPDES permit program.

C. U.S. Department of Agriculture and U.S. Environmental Protection Agency Unified National Strategy for Animal Feeding Operations

On March 9, 1999, the *U.S. Department of Agriculture and the U.S. Environmental Protection Agency Unified National Strategy for Animal Feeding Operations* was published. (This document may be obtained at www.epa.gov/owm/finafost.htm) This Strategy sets out how USDA and EPA intend to address potential pollution from animal feeding operations over the next several years.

1. Voluntary Programs for Smaller Operations

Under this Strategy voluntary programs will be the principal approach for smaller operations that make up 95 percent of the nation's animal feeding industry. These include locally led conservation programs, environmental education program, and technical and financial assistance programs.

2. Comprehensive Nutrient Management Plans

The Strategy sets a goal of developing and implementing Comprehensive Nutrient Management Plans for all animal feeding operations by 2009. The plans are intended to prevent or reduce runoff, through feed management, improved storage and handling of manure, and better land management. The strategy also identifies existing and potential new sources of technical and financial assistance to help develop and implement these plans.

3. Two-Phase Permitting Priorities

About 5 percent of the nation's animal feeding operations will be required to get a NPDES permit. These include operations with more the 1,000 animal units; those which discharge directly into waterways or have other "unacceptable" conditions; and those which contribute significantly to the impairment of a waterbody. The Strategy sets out a two-phase approach for permitting CAFOs (i.e. operations with over 1,000 animal units.) Under Round One, between 2000 and 2005, it establishes that EPA and the NPDES-authorized state programs will give top priority to issuing statewide general NPDES permits, and where appropriate, individual permits to all CAFOs with significant manure production (i.e., greater than 100 animal units). The general permits should be issued by January 2000. Round One permit priorities also apply to operations with smaller than 1,000 animal units that have unacceptable conditions or cause water pollution in watersheds where there are aggregate water impacts from AFOs on the watershed scale. These permits will be issued under EPA's current regulations.

Round Two of the permitting process begin in 2005. It will incorporate any new requirements resulting from revisions to the CAFO permitting regulations and effluent guidelines that are to be rewritten by this time. It will involve the reissuance of general permits for CAFOs with greater than 1,000 animal units and reissuance of individual permits as the original 5-year period expires.

4. Comprehensive Guidance for NPDES Permits

Also, pursuant to the Strategy EPA committed to developing a comprehensive guidance on the NPDES permitting program for both state-authorized programs and EPA-run programs. According to the Strategy this guidance will include such things as a process for establishing schedules for developing Comprehensive Nutrient Management Plans (CNMP); who is required to obtain a permit; elements of a permit; types of permits; clarification of criteria for issuing permits; specific performance measures for CNMPs development and implementation, monitoring, and reporting (including reporting of CNMPs for land application and their implementation, notice of discharges, and spill repose reporting); public notice procedures for CAFOs general, watershed-specific, and individual permits; and a mechanism for public review of and access to CNMPs.

EPA's draft guidance document was just recently published for public comment. It is entitled *Guidance Manual and Example NPDES Permit for Concentrated Animal Feeding Operations (Review Draft), August 6, 1999,* issued by the Office of Wastewater Management, U.S. Environmental Protection Agency. This draft guidance manual can be obtained on the Internet at http://www.epa.gov/owm or by calling the Water Resources Center at (202) 260-7786. Written public comments on the draft guidance manual are due by October 25, 1999. The guidance document discusses such important topics as which animal feeding operations and concentrated animal feeding operations must obtain an NPDES permit; the key elements of an NPDES permit including the comprehensive nutrient management plan, effluent limitation, land application of manure and wastewater, record keeping and reporting requirements; and how to develop and implement a NPDES permit for CAFOs. The guidance manual contains many tables and appendices including the Natural Resources Conservation Service (NRCS) of the United State

Department of Agriculture's Nutrient Management and Nutrient Management Conservation Practice Standards, and an example NPDES permit for CAFOs. According to the NCRS draft document, the NRCS Part 402 Nutrient Management standards may be obtained on the Internet at http://www.nhq.nrcs.usda.gov/BCS/nutri/gm-190.html, and the Nutrient Management Conservation Practice Standards (Code 590) may be obtained at http://www.nhq.nrcs.usda.gov/BCS/nutri/590.html. The guidance relies on the NRCS standards for establishing comprehensive nutrient management plans for NPDES permits.

5. Rewrite Effluent Limitation Rules for Feedlots

EPA is under a court order to issue revised effluent guidelines for poultry and swine by 2001 and for beef and dairy cattle by 2002.

6. Rewrite NPDES Permit Regulations for CAFOs

The Strategy also provides that EPA will be rewriting its NPDES permit program regulations as they apply to CAFOs. Some of the key issues that may be addressed in this rewrite of the rules are establishing specific monitoring and reporting requirements for permitted facilities; clarifying effective requirements for handling manure on-site or off-site; clarifying when AFOs may be required to get NPDES permits; considering large poultry operations, consistent with the size threshold for other animal sectors, as CAFOs regardless of the type of watering or manure handling systems; requiring CAFOs to have an NPDES permit even if they only discharge during a 25-year/24-hour or larger storm event; and exploring alternative approaches to ensuring that corporate entities support the efforts of individual CAFOs to comply with permits and develop and implement CNMPs.

7. Improve Compliance and Enforcement Programs

The Strategy sets out several methods for improving compliance and enforcement programs in areas such as CAFO Compliance Assurance Implementation Plan, Compliance Assistance, CAFO Inspections, and Information Needs for the Regulatory Programs.

II. Clean Air Act

According to MPCA officials, industry, and environmental groups, the Clean Air Act is not currently being used to address emissions from feedlots. There have been some initial discussions by environmental, farm, and community groups about whether concentrated animal feeding operations must comply with various provisions of the Act. However, there appears to be no definitive legal analysis of if and how the Act applies to feedlots. Some initial discussions have revolved around whether Section 112 of the Act, which establishes the "Great Waters" program, might be used to address atmospheric deposition of nitrogen from large-scale feedlots. North Carolina is apparently looking into atmospheric deposition of nitrogen from feedlots into its estuaries. Another idea revolves around the use of Section 111D of the Clean Air Act to list and then limit potential air emission pollutants from feedlots.

The Clean Air Act provides citizens the authority to bring a civil lawsuit against "any person who is alleged to have violated (if there is evidence that the alleged violation has been repeated) or to be in violation of (A) an emission standard, limitation, or schedule established under any permit issued pursuant to title V or under any applicable State implementation plan approved by the Administrator. . . ." 42 U.S.C. § 7604(f)(4). Since it appears that Minnesota's hydrogen sulfide ambient air standard is included in Minnesota's "State implemented plan" approved by EPA, it may be possible for someone to sue under the Clean Water Act authority for violations of this standard. The Eighth Circuit United States Court of Appeals, which covers Minnesota, has at least once upheld citizen authority to sue to enforce state emissions standards or limitations included in the "State implemented plan." See, e.g., *Save Our Health Organizations v. Recomp of Minn.*, 37 F.3d at 1334 (8th Cir. 1994).

A. Further Research Needed

The lack of legal analysis of how the Clean Air Act might apply to feedlots points to an important area needing further research. Legal research analyzing which provisions of the Clean Air Act may impact animal agriculture would be an important part of completing the Generic Environmental Impact Statement on Animal Agriculture.

III. Packers and Stockyards Act

(7 U.S.C. §§ 181, *et seq.;* 9 C.F.R. §§ 201.1, *et seq.*)

A. The Statute

The extent to which the Packers and Stockyards Act can be used to address livestock procurement issues in the changing structure of the livestock markets today is one of the most hotly debated issues in animal agriculture. Many livestock producers are calling for USDA to strengthen its regulation under the Act to prohibit or restrict packers' ownership of feeder livestock, use of captive supply procurement practices, discrimination between producers on the basis size and types of livestock production operations, and concentration of the top packing companies' marketshare.

Congress passed the Packers and Stockyards Act in 1921 to break up the control of the "Beef Trust" and to place controls on five large packing companies that made up that Trust. The Act was designed to address Congress' concern that top five packers were manipulating markets, restricting the flow of foods, controlling the price of meat, defrauding livestock producers and consumers, and crushing competition in the marketplace. With several amendments since 1921, the Packers and Stockyards Act provides a broad multi-purpose regulatory scheme reaching the livestock, poultry and packing industries. The overall goal of the Act is to ensure competitive livestock, meat, and poultry markets.

The Act is found at 7 U.S.C. §§ 181-229. Subchapter II regulates packers, Subchapter III regulates stockyards and stockyard dealers, and Subchapter IV regulates live poultry dealers and handlers. The Act is administered by USDA's Grain Inspection and Packers and Stockyards Administration (GIPSA). The Act gives GIPSA extremely broad investigative, regulatory, and enforcement authority over the packing industry.

1. Current Conditions in Livestock Markets Similar to Those at Time of Enactment

Legislative history shows that the concentration levels in the beef packing industry at the time the P&SA was enacted over 75 years ago were *lower* than the concentration levels today. A 1916 Federal Trade Commission Report found that the "Big Five" packers controlled 82.2 percent of the cattle slaughter and 76.6 percent of the calf slaughter. Today the top five beef packers control as much as 83 percent of the beef slaughter. Similarly, concentration levels of hog slaughter in the top five packing companies today are again rising to the levels that prompted the passage of the Act. According to the 1916 report, the top five packing firms controlled 61.2 percent of the hog slaughter. Today the top four packers control 57 percent and the top seven firms control 75 percent of the hog slaughter. See 61 Cong. Rec. 1863 (1921), and Heffernan, Dr. William, "Consolidation in the Food and Agriculture System: Report to National Farmers Union," February 5, 1999, p. 17.

In the 1920's Congress understood that concentration of market power in the hands of a few packing firms allowed the packers to keep prices to livestock producers low while raising prices

charged for meat. We are experiencing similar trends today. Over the last thirty years we have seen the packers' share of the retail meat dollar more than double while the livestock producer's share of that meat dollar steadily decline. "Beef Price Spread Data" Table 10—Estimated Historical Series for Beef, Choice Yield Grade 3: Retail, Wholesale and Farm Values, Price Spreads and Farmers' Share, USDA Economic Research Service, Stock No. 90006.

2. Prohibition of Unfair and Deceptive Trade Practices

Packers and live poultry dealers are prohibited, with respect to livestock, meat, and meat food products, and livestock products, from taking any of the following actions:

> (a) Engage in or use any unfair unjustly discriminatory, or deceptive practice or device; or
>
> (b) Make or give any undue or unreasonable preference or advantage to any particular person or locality in any respect whatsoever, or subject any particular person or locality to any undue or unreasonable prejudice or disadvantage in any respect whatsoever; or
>
> (c) Sell or otherwise transfer to or for any other packer, or any live poultry dealer or handler, or buy or otherwise receive from or for any other packer or any live poultry dealer of handler any article for the purpose or with the effect of apportioning the supply between any such packers, if such apportionment has the tendency or effect of restraining commerce or creating a monopoly; or
>
> (d) Sell or otherwise transfer to or for any other person, or buy or otherwise receive from or for any other person, any article for the purpose or with the effect of manipulating or controlling prices, or creating a monopoly in the acquisition or, buying, selling, or dealing in, any article, or of restraining commerce; or
>
> (e) Engage in any course of business or do any act for the purpose or with the effect of manipulating or controlling prices, or of creating a monopoly in the acquisition or, buying, selling, or dealing in, any article, or of restraining commerce; or
>
> (f) Conspire, combine, agree, or arrange with any other person (1) to apportion territory for carrying on business, or (2) to apportion purchases or sales of any article, or (3) to manipulate or control prices; or
>
> (g) Conspire, combine, agree, or arrange with any other person to do, or aid or abet the doing of, any act made unlawful by subdivisions (a),(b), (c), (d), or (e) of this section.

7 U.S.C. § 192. It is this broad prohibition of packer practices that many livestock producers argue should be interpreted and enforced by GIPSA to prohibit or restrict packers' ownership of feeder livestock, use of captive supply procurement practices, discrimination between producers on the basis of size and types of livestock production operations, and concentration of the top packing companies' marketshare.

3. Enforcement of Prohibited Trade Practices

If the Secretary of Agriculture has reason to believe that a packer is engaged in practices prohibited under 7 U.S.C. § 192, he has the authority for file a complaint. The charged party has the opportunity to request a hearing on the complaint. Upon finding a violation, the Secretary may assess a civil penalty and issue a cease and desist order. A violation of a final order issued by the Secretary is punishable by fine, imprisonment, or both. An appeal of the Secretary's decision can be taken to the United States Courts of Appeals. See 7 U.S.C. §§ 193-95.

The Secretary of Agriculture has no authority to enforce the trade practices prohibitions of 7 U.S.C. § 192 against live poultry dealers.

Any person who is injured by a violation of 7 U.S.C. § 192 may bring can action in court against the violator for full damages sustained in consequence of the violation. 7 U.S.C. § 209.

4. "Packer" and "Live Poultry Dealer" Definitions

The definition of "packer" is found at 7 U.S.C. § 191. Court cases have determined that this broad definition not only encompasses the big slaughterhouses and meat packers, but also reaches businesses that purchase processed meat for resale in substantial quantities and nationwide supermarket chains that have central facilities that cut up carcasses and process meat.

The definition of a "live poultry dealer" is found at 7 U.S.C. § 182(a)(10). This term encompasses any person or business that obtains live poultry for slaughter whether through purchase or under a poultry growing arrangement.

5. Statutory Trust for Unpaid Cash Sellers

In 1976 Congress amended the Act in an effort to ensure that livestock producers would promptly receive full payment by adding 7 U.S.C. §§ 196 and 228b. Section 192(b) requires that a packer with annual purchases exceeding $500,000 establish a trust fund until full payment has been made by sellers of livestock including cattle, sheep, swine, horses, mules and goats. Poultry sellers and contract growers are similarly protected by the trust provisions of 7 U.S.C. § 197 which were added in 1987.

The trust corpus is made up of livestock and all proceeds of livestock from cash sellers. To preserve a valid claim against the trust, the unpaid seller must file written notice of nonpayment to the packer and file such notice with the Secretary within 30 calendar days of the final date for making payment under 7 U.S.C. § 228b, or within 15 business day of being notified that the payment of a promptly presented check was dishonored. 7 U.S.C. § 196(b).

6. Prompt Payment Requirements

The Packers and Stockyards Act also provide that packers, marketing agencies, and dealers purchasing livestock must deliver to the seller or its duly authorized agent full payment before the close of the next business day following purchase, unless the parties agree otherwise in writing before the purchase of, or the sale is on a grade and yield basis. 7 U.S.C. § 228b. Any delay or attempt to delay payment is an "unfair practice" under 7 U.S.C. § 228b(c). The Secretary does not have specific statutory authority to issue cease and desist orders or to assess penalties for violations of the prompt payment provisions for livestock. However, the Act is enforced as though such specific authority exists.

In 1987 Congress amended the Act to make live poultry dealers subject to the prompt payment provisions. 7 U.S.C. § 228b-1. Failure of live poultry dealers to pay promptly constitutes an unfair practice. With regard to violations of the prompt payment provisions applying to live poultry dealers, the Secretary does have the authority to assess penalties and issue cease and desist orders.

7. Stockyards, Marketing Agencies, and Dealers

Stockyards, marketing agencies, and dealers are also regulated under the Packers and Stockyards Act. Essential definitions relating to the regulation of these entities are found at 7 U.S.C. § 201. Stockyards must post notices stating that they are regulated subject to the provisions of the Act. 7 U.S.C. § 203. Upon "posting" the operator of the stockyard and all market agencies and dealers doing business at the stockyards must register and file schedules of rates and charges. 7 U.S.C. §§ 203, 207, and 209. Bonds are required for most market agencies and dealers. 7 U.S.C. § 204. Marketing agencies and stockyards are required to charge reasonable rates, respond to reasonable requests for services, operate in a reasonable and nondiscriminatory manner, and keep appropriate records. 7 U.S.C. §§ 201-207a. If stockyards or marketing agencies violate these requirements or engage in prohibited practices the Secretary can issue orders, fines, activity suspensions, and rate changes. See 7 U.S.C. §§ 204, 207, 209, 210, 211, 215, 217.

8. Records Requirements

Packers, Stockyards, market agencies, dealers, and live poultry dealers must keep record that fully and correctly disclose all relevant business transactions. The Secretary may prescribe the form and manner in which the records must be kept and a violation is punishable upon conviction by a $5,000 fine or three years in prison or both.

B. The Rules

The rules implementing the Packers and Stockyards Act are found at 9 C.F.R. § 201.1-201.200.

1. Unfair and Deceptive Trade Practices

There are very few rules that pertain to the unfair trade practices section of the Act. The rules that do exist are found at 9 C.F.R. §§ 201.53-201.70. These regulations expand the statutory rules by forbidding such activities as circulation of misleading reports on market conditions or price, use of false weights when livestock are sold on a weight basis, and exchange of information among packers for the purpose of limiting competition. These regulations also impose limitations on packers owning or financing selling agencies.

At recent Farm Crisis Meetings livestock producers have demanded that GIPSA issue more stringent rules implementing the trade practices section of the Act to prohibit or restrict packers' ownership of feeder livestock, use of captive supply procurement practices, and discrimination in pricing methods between producers. A formal petition for rulemaking seeking restrictions on packer ownership of feeder cattle and use of forward contracts and marketing agreements has been published for comment in the Federal Register and is still under consideration by the Secretary of Agriculture. See 62 Fed. Reg. 1845 (Jan. 14, 1997).

2. Packers Ownership and Control of Feedlots

Prior to 1984, packers were prohibited from owning, financing, controlling and managing feedlots. However, a packer could hire the services of a feedlot or have its own livestock fed out at a feedlot. See 9 C.F.R. § 201.70a(1983). Amendments were made to these rules in September 1984. Since that time, packer ownership or control of a feedlot is not a per se violation of the Act. However, guidelines with respect to packers engaging in the business of custom feeding livestock are provided in the rules. 9 C.F.R. § 203.18. These guidelines are designed to encourage packers to take appropriate measure to eliminate conflicts of interest in such circumstances.

3. Bond Requirements

The rules regarding market agency, dealer and packer bonds are found at 9 C.F.R. § 201.27-201.34.

4. Other Stockyard, Marketing Agency and Dealer Rules

Rules dealing with posting of stockyards are found at 9 C.F.R. §§ 201.5-201.6. Rules relating to schedules of rate and charges, registration, accounts and records, services and general issues are found at 9 C.F.R. §§ 201.5-.6, 201.10-.11, 201.43-.49, 201.71-.82, and 201.94-.99.

5. Live Poultry Dealer Rules

(The discussion is this section is taken from Roth, Randi I., "Are You Being Paid the Right Amount?—A poultry Grower's Guide to Getting Information About Earnings," and "How Much did your Birds Really Weigh?—A Poultry Grower's Guide to Laws About Scales," *Farmers Legal Action* Report, Vol. 7, No. 3, 1992). The Packers and Stockyards Act defines "poultry grower" as "any person engaged in the business of raising and caring for live poultry for slaughter by another." 7 U.S.C. § 181(a)(8). The rules implementing the Packers and Stockyards Act require that poultry growers be given basic information about how their pay will be computed.

a. Contracts

Poultry growers are entitled to receive a *written* contract that *clearly specifies* "all terms relating to the payment to be made to the poultry grower." 9 C.F.R. § 201.100(a). "All terms relating to payment" should include all terms relating to bonuses. The law says that the contract must include the following information:

(1) The party liable for condemnations, including those resulting from plant errors.

(2) The method for figuring feed conversion ratios.

(3) The formula or method used to convert condemnations to live weight.

(4) The per unit charges for feed and other inputs furnished by each party.

(5) The factors to be used when grouping or ranking poultry growers.

9 C.F.R. § 201.100(a)(2)(I)-(V). Additionally, poultry growers have a right to receive official United States Department of Agriculture (USDA) condemnation and grading certificates at the time of settlement if the contract provides that USDA condemnations or grades affect the grower's pay. 9 C.F.R. § 201.100(c).

b. Settlement Sheets

Growers have a right to receive "a true and accurate settlement sheet (final accounting)" at the time of settlement. 9 C.F.R. § 201.100(b). The law says that:

> The settlement sheet shall contain *all information necessary to compute the payment due the poultry grower.* For all such arrangements in which the weight of birds affects payment, the settlement sheet shall show, among other things, the number of live birds marketed, the total weight and the average weight of the birds, and the payment per pound.

9 C.F.R. § 201.100(b). The settlement sheet should give poultry growers all information

necessary to compute both the base pay and any bonus.

c. Grouping or Ranking Sheets

Many contracts provide that a ranking system will be one of the factors used to compute the growers' pay. For example, some contracts say that if a grower ranks high on feed conversion efficiency, he or she will receive a higher price per pound for the birds. Ranking systems make the pay formula even more complicated.

The law says that when the contract provides for payment based upon a grouping or ranking formula:

> [The company] shall furnish the poultry grower, at the time of settlement, a copy of a grouping or ranking sheet which shows the grower's precise position in the grouping or ranking sheet for that period. The . . . sheet need not show the names of other growers, but shall show the *actual figures* upon which the grouping or ranking is based for each grower . . . .

9 C.F.R. § 201.100(d).

d. Scale Tickets

Poultry growers have the right to receive a scale ticket whenever their live poultry is weighed by the company. The weight on the ticket should be *machine-printed,* not handwritten. 9 C.F.R. § 201.71(b). Tickets must be issued in at least duplicate form: one copy should be given to the grower, and the other copy should be given to the company. 9 C.F.R. § 201.49. The tickets must be serially numbered and must be used in numerical sequence. *Id.*

Scale tickets must show *all* of the following information:

(1) The name of the agency performing the weighing service.

(2) The name of the live poultry dealer (the company).

(3) The name and address of the grower.

(4) The name or initials of the person who weighed the poultry.

(5) The location of the scale.

(6) The gross weight, tare weight, and net weight.

(7) The date and time when the gross weight and tare weight are determined.

(8) The number of poultry weighed.

9 C.F.R. § 201.49(b)(1)-(8).

If the poultry is being weighed on a vehicle scale, the scale ticket must also show the following

information.

(9) The weather conditions.

(10) Whether the driver was on or off the truck at the time of weighing.

(11) The license number of the truck or the truck number.

9 C.F.R. § 201.49(b)(1)-(11).

e. Scales

The scales that are used to weigh poultry growers' live poultry must be accurate. The rules say that the scales must be "installed, maintained, and operated to insure accurate weights." 9 C.F.R. § 201.71. The scales must be *tested* at least twice every calendar year. 9 C.F.R. § 201.72(a). A form that reports the results of each test and inspection must be filled out in duplicate; one copy must be kept by the company, and the other copy must be kept by the regional office of the Packers and Stockyards Administration. 9 C.F.R. § 201.72(b). The people who operate the scales must be qualified. 9 C.F.R. § 201.73.

f. Care and Promptness In Weighing

The rules require that the company must:

> [E]xercise reasonable care and promptness with respect to loading, transporting, holding, yarding, feeding, watering, weighing, or otherwise handling . . . live poultry to prevent waste of feed, shrinkage, injury, death or other avoidable loss.

9 C.F.R. § 201.82(a). The rules also require that:

> [T]he poultry shall be transported *promptly* after loading and the gross weight for grower payment purposes shall be determined *immediately* upon arrival at the processing plant, holding yard, or other scale normally used for such purposes.

9 C.F.R. § 201.82(b).

IV. Environmental Quality Incentives Program

(16 U.S.C. §§ 3839aa, *et seq.;* 7 C.F.R. §§ 1466.1, *et seq.*)

The Environmental Quality Incentives Program (EQIP) is a USDA conservation program designed to help farmers and ranchers facing soil, water, and other natural resource concerns. EQIP is the USDA's most comprehensive conservation plan, combining the functions of and replacing various agricultural conservation programs and water quality programs. 16 U.S.C. § 3839aa(1). The program's objectives are to maximize the return on environmental dollars spent; provide technical and financial assistance to farmers and ranchers facing serious environmental threats to their land; assist farmers and ranchers in complying with various federal and state environmental laws; and encourage and assist farmers and ranchers in instituting cost-effective practices that enhance environmental quality. 16 U.S.C. § 3839aa(2).

A. Types of Assistance and Conservation Practices

Technical assistance, cost-share payments, incentive payments and education are available to producers who enter into contracts pursuant to this program in which they agree to implement land management, structural, or vegetative practices. 16 U.S.C. § 3839aa-2(a)(1). These types of assistance are defined at 7 C.F.R. § 1466.3. Structural practices are those which involve the "establishment, construction, or installation of a site-specific measure to conserve, protect from degradation, or improve soil, water, or related natural resources." 7 C.F.R. § 1466.3. Animal waste management facilities, tailwater pits, and livestock water developments are among the examples listed. 7 C.F.R. § 1466.3. Producers who implement structural practices are eligible for technical assistance, cost-share payments, and education. 16 U.S.C. § 3839aa-2(a)(2)(A). Land management practices are practices which "require site-specific management techniques and methods to conserve, protect from degradation, or improve soil, water, or related natural resources." 7 C.F.R. § 1466.3. Nutrient management, manure management, and other crop management techniques are among the example provided. 7 C.F.R. § 1466.3. Producers who implement land management practices are eligible for technical assistance, incentive payments, and education. 16 U.S.C. § 3839aa-2(a)(2)(B).

B. Administration

EQIP is a program of the Commodity Credit Corporation (CCC) of the USDA. The Natural Resource Conservation Service (NRCS) and Farm Service Agency (FSA), both agencies of the USDA, are responsible for the administration of EQIP. NRCS is responsible for establishing policies, determining eligibility, making funding decisions, and providing implementation and technical leadership. 7 C.F.R. § 1466.2(b). FSA is charged with administrative procedures regarding applications, contracts, financial matters, and performance reporting. 7 C.F.R. § 1466.2(c).

C. Eligible Areas and Producers

The law places emphasis on priority areas. Priority areas are locally-identified or state-identified areas with particular environmental sensitivity or other significant natural resource concerns. 16 U.S.C. § 3839aa-3; 7 C.F.R. § 1466.5. The statute and the implementing regulations emphasize local involvement in determining priority areas. Government agencies are to work with local work groups who are, in turn, instructed to obtain input from private individuals and organizations when identifying priority areas. 7 C.F.R. § 1466.5(c). Technical, educational, and financial assistance under EQIP may still be available to non-priority areas with significant natural resource concerns. 7 C.F.R. § 1466.5(b). Half of the program funds are to be directed at resource concerns involving livestock production, and the other half is to be distributed among other agricultural conservation concerns. 7 C.F.R. § 1466.4(e). A livestock-related concern is broadly interpreted to mean any on-site or off-site environmental condition "directly related to livestock activity or to livestock manure or waste." 7 C.F.R. § 1466.3. Those engaged in livestock or agricultural production are eligible for the program. Duties of producers are listed at 16 U.S.C. § 3839aa-4. Further program eligibility requirements are described at 7 C.F.R. §1466.4.

D. Limitation on Eligibility

Producers owning or operating large confined livestock operations are not eligible for cost-share payments to construct animal waste storage or treatment facilities. 16 U.S.C. § 3839aa-2(e)(1)(B). CCC is permitted to fund other conservation practices associated with these large operations, as well as technical and educational assistance. 7 C.F.R. § 1466.7(b)(1). The national definition of large confined livestock operation is an operation with more that 1,000 animal unit equivalents. 7 C.F.R. § 1466.7(b)(1). An animal unit is 1,000 pounds of live weight of any given animal or combination of animals. 7 C.F.R. § 1466.3 "The total number of animals confined at all locations of the participant's livestock operation" is the relevant number of livestock for eligibility purposes. 7 C.F.R. § 1466.7(b)(1). The NRCS State conservationist, with guidance from the State technical committee, may alter the definition of large confined livestock operation for that state. 7 C.F.R. § 1466.7(b)(2). The criteria for developing a new definition are listed at 7 C.F.R. § 1466.7(b)(2). Among the factors to be considered are cost-effectiveness of the facility, producer's ability to pay for the cost of the facility; applicable state, tribal, or local environmental laws; characteristics of modern livestock operations; and the size of the operation relative to other such operations in the state or region. 7 C.F.R. § 1466.7(b)(2). Cost-effectiveness and producer ability to pay are to be emphasized in developing the criteria to define large operations. 7 C.F.R. § 1466.7(b)(3). The Chief of NRCS must provide approval and oversight when new definitions are proposed and implemented. Approval rests in part on the need for consistency in the definitions used. 7 C.F.R. § 1466.7(b)(4).

E. Conservation Plan and Contract

Applicants must submit a plan of operations detailing the conservation practices that will be implemented and the objectives to be met. 16 U.S.C. § 3839aa-5; 7 C.F.R. § 1466.6. The plan must include the type of conservation practice(s) to be used and the type(s) of assistance required. The plan essentially becomes the contract. 7 C.F.R. § 1466.6. Contracts must extend at least five years, but cannot be longer than ten years in length. 16 U.S.C. § 3839aa-2(b)(2); 7 C.F.R. § 1466.21(b)(2). Cost-share payments must not exceed 75 percent of the total cost of the practice. 16 U.S.C. § 3839aa-2(e)(1)(A); 7 C.F.R. § 1466.23(a)(1). Cost-share payments for structural practices are unavailable to producers who participate in certain other cost-share programs on the same land. 16 U.S.C. § 3839aa-2(e)(1)(C). Cost-share and incentive payments must not exceed $10,000 for any fiscal year or $50,000 for any multiyear contract unless the Secretary determines that a larger sum is necessary under the circumstances. 16 U.S.C. § 3839aa-7; 7 C.F.R. § 1466.23(b). Producers are limited to one contract per tract of agricultural land at a given time. 7 C.F.R. § 1466.21(d).

V. Nutrient Management Research and Extension Initiative
(7 U.S.C. § 5925a)

This section authorizes the Secretary of Agriculture, in conjunction with the National Agricultural Research, Extension, Education, and Economics Advisory Board, to award research and extension grants to individuals or organizations engaged in specified nutrient management research and extension projects. 7 U.S.C. § 5925a(a). Generally, grant recipients must match any federal funds received by providing at least an equal amount of non-federal funds, but the Secretary has the authority to waive this requirement under certain circumstances. 7 U.S.C. § 5925a(c).

Among the designated projects is research relating to animal waste management and odor control. 7 U.S.C. § 5925a(e)(1). This research must be in the nature of identifying and developing new technologies and disseminating the results. 7 U.S.C. § 5925a(e)(1). Another area is research conducted on water quality and aquatic ecosystems. 7 U.S.C. § 5925a(e)(2). Grants may also be extended to projects investigating animal waste and odor management in rural areas adjacent to urban or suburban areas. 7 U.S.C. § 5925a(e)(3). The statute also provides grants for research conducted on alternative uses of animal waste. 7 U.S.C. § 5925a(e)(5).

VI. Milk Marketing Orders and Regional Dairy Compacts
(7 U.S.C. § 608c; 7 C.F.R. §§ 1000-1199)

A. Federal Milk Marketing Orders

Federal Milk Marketing Orders set minimum prices that must be paid to dairy producers for milk. Because of the structure of the pricing system included in these marketing orders for Class I milk (milk used in fluid milk products), most Minnesota dairy producers and dairy industry representatives believe that the orders, for many years, have discriminated against Minnesota producers by providing unjust incentives to increase milk production in other regions of the country and have contributed to the loss of well over 10,000 Minnesota dairy farms since 1985. An important legal challenge to the Class I milk pricing structure, in which the minimum price for fluid milk increases with the distance of the orders' marketing area from Eau Claire, Wisconsin, was litigated by the Minnesota Milk Producers Association over the last decade. See, e.g., *Minnesota Milk Producers Ass'n v. Glickman*, 981 F.Supp. 1224. (Dist. of Minn. 1997); *reversed* at 153 F.3d 632 (8 th Cir. 1998).

The statutory authority for federal milk marketing orders is found at 7 U.S.C. § 608c. The rules implementing the more 30 marketing orders covering various regions of the country are located at 7 C.F.R. §§ 1000-1199. New consolidated milk marketing orders have been published in the federal register and voted on by dairy producers across the country. These new orders are scheduled to become effective October 1, 1999, if, as expected, the producer vote supports these new orders. These consolidated and revised orders are being issued in response to a directive by Congress as part of the Federal Agricultural Improvement and Reform Act of 1996, Public Law No. 104-127, 110 Stat. 915-916, Section 143, codified at 7 U.S.C. § 1253.

The federal milk marketing order system is extremely complex. The following is a very brief summary of key provisions of this system as they relate to prices paid to producers. Each milk marketing order covers a different marketing area of the country. All milk sold within a particular order's marketing area by handlers associated with that order must comply with the pricing provisions of the order. The milk marketing orders set the minimum price that handlers, those entities which buy milk from producers, have to pay for the various classes of milk defined in the orders. Separate minimum prices are set in the orders for each class of milk, including milk used for fluid products, milk used for soft dairy products such as ice cream and soft cheeses, milk used for hard cheese, and milk used for butter and powder. The base price for each class of milk varies from month to month according to a formula established in the orders that is designed to measure supply and demand conditions for milk. Handlers who buy dairy products must account to the appropriate marketing order administrator for the minimum price for all milk used in each of the classes. The total milk receipts and the percent utilization of milk in each of the classes are used to calculate the weighted average value of the milk distributed in each order's marketing area. This weighted average value is called the "blend price." At least the minimum blend price must be paid to all producers who deliver milk to handlers regulated by the order, with some specific adjustments made for the handler's location. See 7 U.S.C. § 608c(5).

B. Regional Dairy Compacts

As part of the Federal Agriculture Improvement and Reform Act of 1996, Congress consented to the Northeast Interstate Dairy Compact entered into among the States of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont. Public Law No. 104-127, Section 147, 110 Stat. 919, codified at 7 U.S.C. § 7256. The Northeast Interstate Dairy Compact allows the participating states to increase the minimum price that handlers must pay for Class I (fluid) milk, if the minimum price under the federal milk marketing order system drops below a certain level. Many Minnesota dairy producers and industry representatives believe that the Northeast Interstate Dairy Compact adversely impacts Minnesota producers by providing a financial incentive for excess milk production in the Northeast, which competes on a national market with milk produced in Minnesota.

VII. Livestock and Dairy Checkoff Programs

(Pork: 7 U.S.C. §§ 4801-4819 and 7 C.F.R. §§ 1230.1-.9; Beef: 7 U.S.C. §§ 2901-2911 and 7 C.F.R. §§ 1260.101-.640; Dairy: 7 U.S.C. §§ 4501, *et seq.*, and 7 C.F.R. pt. 1150)

Congress established programs to provide funding for promotion, research, and consumer information for pork, beef, and dairy products. Funding for these programs is raised by requiring pork, beef, and dairy producers to pay either a fixed dollar amount per animal sold or a percentage of the income from the sale of livestock and dairy products. These mandatory programs requiring producers to pay for promotion, research, and consumer information projects are known as checkoff programs.

Each checkoff program has its own statutory and regulatory authority. The pork checkoff program statutory authority is found at 7 U.S.C. §§ 4801-4819 and the regulatory authority at 7 C.F.R. §§ 1230.1-.91. The beef checkoff program authorities are found at 7 U.S.C. §§ 2901-2911 and 7 C.F.R. §§ 1260.101-.640. The dairy checkoff program authorities are found at 7 U.S.C. §§ 4501, *et seq.*, and 7 C.F.R. pt. 1150). There are also checkoff programs that apply to some crops.

Producers were allowed to vote on whether or not to continue with the initial orders (regulations) implementing the various checkoff programs shortly after those orders where put into place. The beef, pork, and dairy checkoff orders were voted on by producers during the mid- to late 1980s.

Both the authorizing statutes and the checkoff program orders (regulations) define the types of promotion, research, and consumer information programs that may be funded with producers' checkoff dollars. Certain uses of checkoff funds are also explicitly prohibited. Generally, checkoff funds may not be used for lobbying efforts. Some of the checkoff programs describe the types of organizations that may be granted checkoff funds.

The checkoff programs require that the mandated producer payments be made either directly by the producer or by the purchaser of the livestock or milk on behalf of the producer to a board that

administers the checkoff program. Each checkoff program has its own administering board. This board ensures collection of the mandated producer payments and makes decisions regarding which promotion, research, and consumer information projects will be funded.

The checkoff programs establish significant penalties for producers who do not make the required payments. There are administrative procedures for the assessment of these penalties which provide for producer appeals.

The authorizing statutes for the checkoff programs also require the Secretary of Agriculture to conduct a producer referendum to terminate or amend the checkoff program orders if a specified number of producers request such a vote. For example, on the pork checkoff program, a referendum must be held if the Secretary receives petitions calling for the referendum from 15 percent of pork producers paying the checkoff. To obtain a mandatory referendum on the beef checkoff, 10 percent of producers must sign petitions calling for the termination or amendment referendum.

The beef, pork, and dairy checkoff programs all have come under severe criticism from producers. Critics assert that the programs have not resulted in improved prices or market conditions for livestock and dairy; that the organizations which receive the vast majority of the checkoff funds do not maintain adequate separation of the checkoff-funded programs and their policy advocacy programs; and that checkoff dollars are sometimes used to fund promotion, research, and consumer information programs that are detrimental to family farm producers. Petitions calling for a referendum on the termination of the pork checkoff program were submitted to USDA in late May 1999. USDA is currently in the process of verifying the signatures on those petitions to determine whether a termination referendum will be conducted. Petitions calling for a referendum on the termination of the beef checkoff program are now being circulated. Organizations sponsoring that petition drive expect to obtain a sufficient number of beef producers' signatures to submit the petition request to USDA sometime in the next few months.

VIII. Agricultural Credit Programs

A. USDA Farm Service Agency Credit Programs

(7 U.S.C. §§ 1921-2006; 7 C.F.R. § 1900-1999)

USDA's Farm Service Agency (FSA) has several Farm Loan Programs that may be available for livestock, dairy, and poultry producers. These programs include the Farm Ownership Loan Program through which loans are made for real estate purchases and improvements; the Operating Loan Program through which loans are made for such purposes as operating expenses and purchases of equipment and livestock; and the Emergency Loan Programs in which loans are made to cover the losses caused by natural disasters. FSA has both direct loan programs through which the agency provides loans directly to the farmer, and guaranteed loan programs through which the agency guarantees loans made by other lenders such as the Farm Credit System and private banks. Both the direct loan programs and the guaranteed loan programs include loan servicing programs that authorize restructuring of debt. The statutes authorizing the FSA lending programs are found at 7 U.S.C. §§ 1921-2006. There are extensive regulations controlling these programs, which are found at 7 C.F.R. §§ 1900-1999. For more detailed discussion of the FSA farm loan programs see (FLAG, 1990) and (FLAG, 1999).

Because FSA is intended to be the lender of last resort making loans to family farmers who cannot obtain credit elsewhere are reasonable rates and terms, there has been significant criticism of FSA for making direct loans to or guaranteeing loans for farmers building capital intensive large-scale livestock and poultry production facilities.

B. Farm Credit System

(12 U.S.C. §§ 2001-2279aa-14; 12 C.F.R. §§ 600-650)

The Farm Credit System also makes loans to farmers and farm cooperatives. The Farm Credit System lenders are quasi-governmental lending institutions whose programs are overseen by the Farm Credit Administration, which is a federal government agency. The federal statutes controlling Farm Credit System lending are found at 12 U.S.C. §§ 2001-2279aa-14. The Farm Credit Administration Rules affecting Farm Credit System loan programs are found at 12 C.F.R. §§ 600-650. For cites to articles providing more detailed discussion of Farm Credit System, see "Credit Programs, Farm Credit System" below.

C. Need for Further Research on Credit and Grant Programs

The limited resources provided for this literature review did not allow for an exhaustive study of all state and federal loan and grant programs that may be available for livestock, dairy, and poultry producers or businesses that deal with marketing and processing of livestock, dairy, and poultry. Because access to capital is extremely important in animal agriculture and the structure of government programs that are designed to fill in the gaps of private capital sources can play a key role in encouraging certain types of animal agricultural production, processing, and marketing, we recommend that further research on grant and loan programs be conducted.

The Farm Credit System lending practices in the livestock and poultry production sector have recently come under increasing criticism because some believe they have emphasized lending to producers who use large-scale capital-intensive production systems and participate in vertically integrated marketing systems.

Question 1b: How effective are these actions in mitigating problems or encouraging desired outcomes?

The results of the literature review in answer to all of the Role of Government questions on the effectiveness of policies and programs were small. The literature that was found addressed very narrow policies. A comprehensive study of any single area of legislation would contribute greatly to the knowledge base. The discussion below describes the articles that were reviewed. With the exception of the Edelman et al., stratified survey, the writings are primarily observation and opinion analysis conducted by experts in the policy fields.

In states where policies have been put in place to reduce the impact of concentrated livestock systems on the environment, communities, and neighbors, a major outcome has been to heighten the level of conflict between operators, owners, neighbors and regulators. Edelman et al., (June 1999) working as a National Task Force of Extension Specialists representing all regions of the nation, designed a survey instrument to determine the impact policies have had across the US. This stratified survey is a result of a project organized under the auspices of the National Policy Education Committee. One extension specialist in each state was asked to contact land grant university colleagues and state agency staff with appropriate expertise to respond to the survey. The National Center for Agricultural Law Research and Information is working with the Task Force to complete the data set and verify selected information in the national database.

Survey results were not verified at this writing. However, the summary is based on 48 states that have responded as of June 18, 1999. The survey finds that:

- 38 states indicate that confinement animal feedlot operations are controversial in their state;
- 39 states indicate increased incidences of conflict and attention in the media;
- 22 states indicate legislation was proposed during the past year
- 19 states indicate court action involving concentrated livestock operations; and
- 16 states have new ordinances or policies passed by local jurisdictions.

Swine, followed by dairy and chicken-broilers, are the most controversial. The survey provides a recent, comprehensive summary of the level of governmental oversight for CAFOs.

Lovell and Kuch (1999) discuss the role of the Environmental Protection Agency (EPA) in animal agriculture. They identify, in their opinion, some of the gaps and flaws in the present EPA policies utilized for Concentrated Animal Feeding Operations (CAFOs). Requirements for land application of manure by CAFOs can be permitted based on the permit writer's best professional judgement. As a result, permit requirements for land applications vary from state to state and from permit to permit. Furthermore, they point out, that land applications by other animal feeding operations not meeting the definition of CAFOs and by other farms obtaining manure from CAFOs are not currently subject to regulation.

Lovell and Kuch further state that nutrient management plans that incorporate testing of soil and

manure for nutrient levels can help determine the correct agronomic rate of combined fertilizer and manure application. Without such testing there is a tendency to underestimate the value of nutrients in manure leading to over application of manure and fertilizer. They question if all NPDES permits should require a nutrient management plan and if so should levels of application above crop requirements then be considered point source discharges. Currently most nutrient management plans focus on nitrogen.

When is comes to regulation of animal agriculture, one size does not fit all as observed by Lovell and Kuch. Geographic heterogeneity influences pollution problems stemming from animal agriculture such as soil type, climate and topography, causing considerable variability in both problems and management practices. They suggest that types of farms found in watersheds, including their degree of vertical integration, scale of operation and the proximity to cropland and pasture also vary geographically and affect the use and profitability of alternative waste management practices. This being the case, they pose the questions; should regulations be on an individual farm basis (numbers and types of animals per farm), or should regulation be based on the entire population of animals permissible within a watershed, or perhaps on all nutrient sources within the watershed.

Lovell and Kuch summarize by addressing the debate of the role of government (in this case EPA) by stating the question of trade-off between addressing geographic heterogeneity in soils, climate, and animal production on one hand and accountability and administrative feasibility on the other. Will policies be able to assure that the people who make the production decisions and have access to capital bear the cost of managing the waste that result from their location and production decisions? What effect will environmental regulations have on the structure of American agriculture?

Matthey and Royer (1999) looked at a Nebraska policy regulating corporations and syndicates and the policies impact on the Nebraska hog industry. In 1982 Nebraska enacted Initiative 300 (I300) an initiative to regulate non-family farm or ranch corporations and syndicates including limited partnerships. The authors present the hypothesis that the elimination of the corporate organizational option in Nebraska has reduced the organizational flexibility that is available to hog farmers in other states and that was available before I300 was passed. They conclude that I300 has slowed but not stopped the growth of the Nebraska hog industry and its associated economic development. They recognize the effects on the hog industry are not the results of a single variable such as I300 since the initiative coincided with major technological changes in the hog industry.

Norris and Thurow (1997) provide a discussion of the agricultural setting and environmental problems in animal agriculture and how they affect both the economics of livestock and the environment. In an overview of federal, state and local policies affecting concentrated animal feeding operations (CAFOs) they make a case for environmental policies in animal agriculture providing little impact on the environment primarily because of inflexibility. They observe that EQIP forces livestock producers to follow only NRCS-approved standard technologies for

financial reasons even though research or experience in other countries may have greater effectiveness. State and local policies use numbers of animals per acre as a way to reduce the risks of excess nutrients on surface and ground water, even though species and manure management technologies differ. Also NPDES policy requires that once a CAFO is designated as a point source, according to number of animal units, it is subject to a no discharge performance standard to which no other discharger regulated by NPDES is held.

Norris and Thurow describe the potential for flexible incentives (policies), especially at the state and federal levels, to minimize environmental and nuisance damages from animal agriculture and to enhance the environment. Programs like EQIP could be used not just to help offset farm-level costs of complying with environmental standards but also to steer animal production to those areas which are more suitable both environmentally and economically; and to areas in which the long-term viability of the livestock industry can be assured with some degree of confidence

Outlaw et al.(1993) make a case that the effects of waste management regulations vary from state to state and for different size diary systems. This variance can affect both structural change within the diary industry and compliance with the spirit of the provisions of the Clean Water Act. Associated with this restructuring will be the requirement for increased investment. Several options exist for government to facilitate this transition including expanded technical assistance and education programs, investment tax credits, federal-state cost sharing and research on alternative waste management technologies. They emphasize the importance of minimizing risk during this change and argue that farmers should be given flexibility in meeting water quality performance standards.

Question 2a: What are the government actions and policies of the past, present and future that relate to economics, profitability, size and location; and what are the intended affects of these actions and policies?

I. Introduction

A. Role of Government Significant

Throughout American history there has been a tradition of government support for and involvement in agriculture. Benedict (1953) provides the standard history. For a description of this historical role from a legal perspective, see, for a short version, Pedersen & Meyer (1998), and for an impressive multi-volume approach Harl (updated through 1998).

The government's support for agriculture, already relatively large in comparison to the government's role in the rest of the economy, increased significantly during the Great Depression. Historians Finegold & Skocpol (1995), economist Pasour (1990), and public policy analysts (Congressional Research Service, 1984) note the New Deal as a turning point in this regard. As noted by one public policy analyst, the United States is in agriculture and seems unable to get out. (Rapp, 1988). Consequently, the amount of government regulation in agriculture generally, and in animal agriculture in particular, is quite large. The general scope of this role is summarized in legal terms by Looney (1993). Walters (1982), a legal scholar, observes that to bring a hamburger to a table involves some three hundred statutory federal programs. For a more concise policy review, see Kennedy & Visser (1990)

The literature attempting to survey the role of government is itself significant -- and is especially prompted by writers who analyze possible reforms. The years immediately preceding a Farm Bill seem to spark significant amounts of analysis. Sumner (1995) provides such a collection from economists. Influential academic examinations of federal farm policy include Tweeten (1979), Knutson et al (1998), and Helmberger (1991). For a comparative view from the perspective of a political scientist, see Bonanno et al (1990), Bonanno (1987), Bonanno (1991) and from sociology, see Gilbert & Howe (1991), Friedman & McMichael (1989) and Buttel & Goodman (1989). A more critical economic academic economic view is presented by Constance et al. (1990).

B. Rationale for Government Regulation

The reason, or rationale, for government involvement in agriculture generally can be reduced to several frequently mentioned rationales (noted below). The rationales apply with varying degrees of importance to animal agriculture.

Before discussing the rationales, several points should be noted. First, several rationales mentioned below contradict one another. It is not surprising therefore, that the policies themselves often seem to counteract each other.

Second, the rationale provided for farm policy does not, of course necessarily correspond with the reason policies were created. A large literature, typically written by political scientists, addresses the political origins of the role of government in agriculture. For a recent effort see Browne (1995), and for an influential earlier analysis see Lowi (1964).

Third, discussions about the rationale for and effect of the government's role in agricultural, especially if the analysis is by an economist, often rest on efficiency concerns. A number of authors are quite explicit in their view that the government should have very little role agriculture, in particular because government almost always makes markets less efficient. (Pasour 1990). This type of argument can be found among other scholars -- including for example those that look at agricultural policy from a legal perspective. (Chen 1995) While not often explicitly addressed in the literature on agricultural policy, a number of authors, including economists, argue that markets themselves sometimes create inefficient results, that efficiency can be defined in a number of ways, and that, ultimately, other considerations may be more important in a particular case than efficiency. (Kuttner, 1996; Kuttner,1989; Christy, 1996)

Fourth, in a field of writing dominated by academic experts the legitimate role that the public views of democratic society play in determining the role of government in animal agriculture is easily overlooked. Much academic writing on farm policy tends to ignore the democratic underpinnings of any legitimate public policy. A number of authors have addressed the dilemma of accommodating both democratic politics and free markets. Among the most impressive, perhaps is Schumpeter (1943, 1961).

The following are common rationales for a government role in agriculture.

1. Support of Farm Income and Prices

Agricultural policy directly regulates farm prices and income. (Knutson et al., 1998; Looney, 1993; Wright,1995; Tweeten, 1995) More specifically, price regulation aims to increase both farm prices and farm income. This support is needed, it is often argued, because farmers face relatively unique pressures on their income. (Bonnen) While most commonly associated with crop policy, this aspect of farm policy also regulates some livestock pricing, such as milk. In addition, these policies indirectly affect livestock production, especially in the sense that farm policy affects the price of feedgrains.

Critics sometimes suggest that farm income and price support is merely an ill-advised form of income redistribution. (Pasour, 1990) Such support is not justified, following this argument, because the average income of farmers now roughly equals that of nonfarmers, and that many farmers now earn the bulk of their income from nonfarm sources. At the extreme, those who farm and also rely on off-farm income are described as not really farmers at all. (Knutson et al., 1998) It is notable, however, that a substantial portion of farmers continue to live in poverty, and that low income farmers that work off the farm to supplement their incomes continue to

work an average of over 40 hours per week on the farm. (Carpenter & Roth, 1996) For discussion of farmer poverty see USDA (1993), Davidson (1990), and Debertin & Infanger (1989).

2. Stabilize Prices and Manage Risks

Agricultural production is notoriously unstable; so too are agricultural prices. (Knutson et al., 1998; Collender, 1999; Wright, 1995) Much agricultural policy is aimed at reducing the volatility in agricultural prices and income. (Tweeten, 1995; Houck, 1990) Stability may be used to increase prices or decrease them. Risk management is thus also an important rationale for agricultural policy. Federal Crop Insurance and other disaster programs generally target crop production. As is the case with farm income supports, these programs have a significant indirect effect on animal agriculture.

3. Increase Agricultural Production

A large portion of farm policy has sought to increase farm production and agricultural sales. (Knutson et al., 1998) Included in this area of policy, for example, is research and extension, and trade policy.

4. Food Safety and Consumer Protection

Many policies are directed at maintaining a safe food supply. (Knutson et al., 1998) USDA policies, in particular, are important for meat production. (Looney, 1993)

5. Conservation and the Environment

Soil and water conservation and protection of the environment have been long-standing concerns for those creating farm policy. (Knutson et al., 1998) They have become even more important in recent decades as broader social goals affect farm policy and play an ever increasing role in farm bill debates. (Looney, 1993; Kicks, 1996)

6. Correcting Market Failures -- Credit, Competition

A more general justification for public policies that affect farm production are those that seek to correct market failures.(Wright, 1995; Knutson et al., 1998; Pasour, 1990) Federal credit policies, for example, have been designed to relieve a problem of lack of credit for agriculture. Under this category as well are those efforts that seek to protect producers from unfair treatment. For example, livestock producers are protected in various ways by the Packers and Stockyards Administration, a part of USDA. (Looney, 1993)

7. Family Farming and the Structure of Agriculture

A number of agricultural policies have been justified explicitly on the basis of preserving a family-based system of agriculture in the United States. (Looney, 1993; Wright, 1995) Economists and those strongly influenced by economic thinking are frequently skeptical of these

concerns.(Tweeten,1995) Chen (1995), a legal scholar, makes economic arguments against any programs to affect the structure of agriculture. Typical of economists may be Knutson et al. (1998) who observe flatly that there are "too many" farmers in the United States. Knutson et al. (1989), Boehlje (1987), and Tweeten (1990) present representative economics-based doubts about the merits of the arguments used to defend family-based agriculture.

While academics tend to be skeptical about this justification, it continues to be important to the general public. (Knutson et al., 1998). Family farming retains broad support among the public. The survival and possible demise of family farming thus creates what one historian has called a "central theme" in agricultural history. (Kirkendall, 1984) Sophisticated surveys show the population to favor government programs that seek to preserve family-based agriculture. (Dalecki & Coughenour, 1992) A significant literature also discusses the merits of maintaining family farming. (Comstock, 1987). For a brief view, see Hightower (1987). For a more detailed look, Berry (1977) makes a moral and cultural case, and Strange (1988), a more populist economic case for family farming. This support is probably linked with a reverence for agrarianism in general. The commitment to and support for agrarianism has deep roots in American and western political thinking -- and can be directly contrasted to a more industrial agriculture.. (Montmarquet, 1989) For one of the many discussions of how to define family farming, see Mooney (1988).

8. Other Social Concerns

Some government intervention reflects other social concerns. This includes, for example, animal welfare statutes. Moral and other social concerns are often the center of agricultural disputes. (Shepard, 1984)

C. Main Policy Areas for the Role of Government

The remainder of this document focuses on several specific areas of farm policy that create a role for government in agriculture or that suggest important lessons for the role of government in agriculture. These areas are: (1) domestic farm programs; (2) conservation and environmental programs; 3) trade policy; (4) marketing and demand expansion programs; (5) food assistance, nutrition and safety programs; (6) credit programs; (7) disaster assistance and risk management; (8) tax policy; (9) regulation of conduct with animals; (10) regulation of contracts and sales; (11) corporate farming laws; (12) organic and sustainable products and direct marketing.

In most instances government regulation means being subjected to administrative law. A very large literature describes the rights of those subject to government regulation. For a taste of the general way in which administrative law affects agriculture, see Kelley (1993), Kelley (1994).

II. Domestic Farm Programs

Domestic farm programs are designed to raise or stabilize farm prices and incomes. (Knutson et al., 1989). These programs include price supports, income supports, and loan programs, and have historically provided billions of dollars annually to farmers. (Pedersen & Meyer 1995; Shields & Wescott, 1998; (Innes, 1995)

There is an extensive discussion of the impacts of commodity programs, and of the 1996 Federal Agricultural Improvement and Reform Act reforms of these programs. (Wesctott & Young 1997; Orden, Paarlberg & Roe; Zulauf et al., 1996; Watkinson & Sheely, 1996; Shields & Wescott, 1998; (Kastens & Feathersone; Knutson et al., 1996; Orden, Paalberg, Roe, 1996; Kelley 1997) While some viewed the 1996 FAIR Act as a major departure from past policy, other analysts suspect that similar programs will remain in place. (Browne, Allen & Schweikhardt 1997; Knutson et al., 1996) This discussion often analyzes the effects of the program on crop choices, or the economic effect of the payments themselves -- for example noting that the payments have largely been capitalized into land values. (Schertz and Johnston, 1998) Direct benefits to animal agriculture producers might create similar difficulties.

Generally farm program benefits have gone to larger farms and likely have benefited larger operations more than modestly sized farms.. (Lin et al., 1981; Goldsmith & Dissart 1998) Along with the total cost of the programs, this may have been their most controversial aspect. Were similar benefits to be provided to animal agriculture producers, the extent to which the benefits are targeted would be of prime importance. The limited and largely ineffective targeting of crop program payments creates administrative difficulties for USDA (Flinchbaugh & Edelman (1995) Tweeten & White (1995) discuss general principles for targeting payments. For their part, surveys suggest that farmers tend to support a reduction in government intervention in agriculture generally, but also believe that payments to larger operations should be reduced so that smaller operations would not face reductions. (Martin et al., 1995) For a discussion of some of the difficulties in targeting benefits, see Summer (1990).

Typical commodity programs do not include livestock. Thus, production flexibility contract payments, nonrecourse marking assistance loan, and loan deficiency payments, which amount to billions of dollars of assistance yearly, target crop production, not animal agriculture. (Shields & Wescott 1998) (Pedersen & Meyer 1995)

Recently, however, USDA has provided direct funds for hog producers. In August 1999 $100 million will be distributed to producers. This is in addition to $50 million provided earlier in 1999. The amount was capped at $5000 per producer and was aimed at those operations that sold less than 2500 hogs annually. (AP 1999).

III. Conservation and Environmental Programs

Considerable government attention goes to policies that are designed to designed to conserve or regulate natural agricultural resources and protect the environment. (Knutson et al., 1989). For a general summary of the regulation of the use and disposal of livestock and poultry waste from perspective of USDA, see Busfield (1990). Some critics argue, in fact, that conservation would be the primary purpose of farm program spending. (Chen 1995)

Most observers agree that the role of government in the realm of environmental policy for animal agriculture is bound to increase in the near future. See, for example, the extensive discussion in U.S. Senate (1997)

The present role of government in conservation and environmental protection might be divided into the following several categories: (1) USDA programs; (2) EPA and state regulation of animal feeding operations; (3) liability issues; and (4) other concerns. After these roles are discussed, the next section looks at some of the literature aiming to provide guidance for future efforts.

A. USDA Programs

USDA programs, including those affecting animal agriculture, target conservation and environmental concerns in a number of ways. (Davidson,1989; Ogg 1996) USDA, for example, is a major source of assistance, education, and technical assistance. Programs include Environmental Quality Inceptive Program (EQIP), Conservation Reserve Program, Wetland Reserve Program, and Wildlife Habitat Incentive Program. A number of the main conservation policies, for example conservation compliance, swampbuster, and sodbuster, the Conservation Reserve Program, and the Wetland Reserve Program, tend to target crop production, not animal agriculture.

EQIP, established in 1996 by the FAIR Act, may be the most important of the USDA programs. Kuch & Ogg (1996) EQIP combined the functions of several other programs to encourage farmer and ranchers to adopt practices that reduce environmental and resource problems through targeted 5-10 year contracts providing education, technical assistance, and financial assistance. Congress authorized substantial resources for EQIP and required that half of all EQIP funds be devoted to conservation practices related to livestock production. The Act requires that maximum environmental benefits be achieved per dollar spent, and also requires that large confined livestock operations be ineligible for cost-sharing to construct animal waste management facilities. (Osborne, 1996) The definition of large confined livestock operation proved especially contentious for USDA. It seems certain that future subsidies or payments designed to address environmental problems in animal agriculture will trigger disputes about the extent to which the subsidies should go to large operations.

B. EPA and State Regulation

For a discussion of EPA permitting of Confined Animal Feeding Operations, see Frarey (1993), Kelley & Maternowski (1994), Centner (1999). For a critique that argues that it has failed to protect water well enough, see Zaring (1996).

A summary of the Minnesota approach of permitting large hog operations from a legal perspective is provided by Kelley (1994). The Clean Water Act generally is analyzed in Healy (1997). A recent case that analyzes what is a point source for the purpose of the Act is summarized in Mollnow (1996).

A growing literature discusses the parallel efforts of other states. In recent years government has pursued an expansive effort to address agricultural nonpoint source pollution, and in particular animal agriculture runoff. The main focus has been a voluntary program intended to assist farmer in protecting environmental resources while maintaining viable farm operations. This extensive program is summarized in Moore (1999).

A new and potentially quite restrictive program in Pennsylvania is described by Favero & Abdalla. For an early assessment of the program in Texas, see Planned Intervention (1993). Regulation in Virginia is criticized as a failure in Almeida (1998). Wisconsin's efforts are described in Heil (1997).

North Carolina requires a comprehensive management plan for livestock operations. Large producers must develop a waste management plan, attend training sessions and pass a test to apply hog waste to land. This effort is evaluated by Pierce and Ramsey and Hoban et al. (Feitshans, 1997). A different author is critical of North Carolina's effort in this regard, and another author describes policies in North Carolina as a legal injustice that promoted industrial swine production. (Moran, 1999) Failure of North Carolina to regulate well is claimed by Burns (1996). Furuseth (1997) argues that the rise of hog contracting in North Carolina was actively encouraged by the state.

For a summary of laws regulating production of pork in Iowa, North Carolina, Minnesota, Illinois, Indian, Nebraska, Missouri, South Dakota, and Oklahoma, including permits, water quality, odor regulation, nuisance, and enforcement, see Dummermuch (1997).

In addition, several authors have analyzed how the general US approach to agriculture runoff compares with that of other countries. For a comparison with the United Kingdom, for example, see Pratt et al., (1997). For a brief summary of the environmental element of EC agricultural policy, see Bonanno (1991).

EPA and USDA recently announced a Clean Water Action Plan. The plan is designed to be a "guidepost for future national water quality policy" involving a shifting policy to emphasize control of nonpoint sources of pollution. (Ribaudo & Horan, 1998) The new initiative aims to work within the context of existing laws and programs. In October 1997 EPA and USDA were instructed to develop the plan. The plan places particular emphasis on the management of animal waste. EPA will use current regulatory authority to address standards and permits for the

larger animal operations. EPA and USDA are to develop a unified national strategy to minimize the environmental risk and public health impact of AFOs. At present most programs are not integrated. Feitshans & King (1999) also analyze EPA plans

One notable aspect of the cooperation between USDA and EPA is the perception of a significant culture difference between the two agencies when it comes to enforcement of environmental laws for agriculture. USDA is perceived as pro-farmer and as preferring voluntary programs. EPA is thought to be pro-consumer and preferring command and control. (Torres, 1989) There are indications, however, that USDA may be becoming a more conservation-focused department. (Waanders, 1999) In any case, additional regulation at the federal level probably needs to take into account the agency that will implement the regulatory or incentive program.

Finally, the Second Circuit has concluded that liquid manure spreading from a dairy farm can be a point source within the meaning of the Clean Water Act. (Concerned Areas Residents for the Environment v. Southview Farm)

C. Liability Issues

There is a general sense that legal liability for environmental violations in agriculture is on the rise. (Marberry, 1995; Knutson et al., 1998) Certainly the environmental problems associated with animal agriculture, especially concentrated livestock production, rise to a level that can trigger legal liability. (U.S. Senate Committee on Agriculture, 1997; Marks,1998; GAO, 1995) Each of the commonly discussed environmental problems associated with animal agriculture -- including odors from facilities or lagoons or fields; overapplication of manure, leaking lagoons or other facilities, runoff, and the like -- presents problems significant enough to allow courts to intervene. There is also no doubt that some neighbors are upset enough about some of the operations to pursue litigation. For a journalistic account, see Agrinews (1998) and Blind (1999). One agricultural historian, R. Douglas Hurt, believes the hog odor issues is the most divisive ever in agriculture. (Smith, 1998) For a summary of the potential legal issues involved, see Voogt (1998). For an account of a recent judgment against Continental Grain, see Cornfeld (1999).

Nuisance law, the main legal remedy in such cases, is summarized by Pedersen & Meyer (1995). Nuisance and other legal actions, however, have been limited somewhat by various state Right to Farm laws. For a legal discussion of some of the relative advantages and disadvantages of right-to-farm laws, and a discussion of the extent to which courts have been willing to enforce the Right to Farm Laws, see Hamilton (1992), Hamilton & Bolte (1998), DeLind (1995), Vukina et al. (1996). State governments have increasingly looked to alter legal liability rules for livestock waste. Some states have shown an interest in altering these statutes in various ways. Some Virginia programs that somewhat unique are summarized in Richardson & Geyer (1992). Various programs in New York law is discussed in detail in Moore (1997).

Of particular interest is the invalidation of Iowa's right to farm law as a violation of the Fifth Amendment of the Untied State Constitution. The potential impact of this decision on other states is analyzed in several places. (McEowen & Harl 1998; Hill 1997) Such analysis is inevitably speculative -- especially when it is applied to possible court action in other states. As

a legal matter the action by the Iowa State Supreme Court affects only Iowa law.

As time goes on other legal liability issues are sure to arise. For example, as producers increasingly contract to have waste removed to another locations, the specific legal responsibilities in these agreements may prove to be controversial. Such agreements are analyzed in Kelley & Lawler (1995).

D. Cost and Effect of Environmental Regulation

Research has begun to ask the question of what environmental regulation of animal agriculture actually costs. Mo and Abdalla (1998) studied the extent to which environmental regulations had an impact on hog inventory growth. They found that the regulations did not have a strong impact. A study of dairies in a highly regulated region of Florida found, however, that costs were raised by roughly $1.15 per hundredweight. One interesting aspect of the Florida study is that more farmers reported a decline in the size of the herd as a result of the regulations than an increase in the herd. (Schmitz et al.,1995). Other economists are working to determine a method of measuring the impact of environmental regulations. (Dumas & Schmitz, 1995) Kashmanian & Rynk (1998), for example, have examined the necessary subsidy to convince poultry growers to compost and Westenbarger & Letson (1995) have looked at comparative costs for dealing with animal waste under strict controls.

In theory, it is possible that production is literally limited due to environmental regulations. As Haley et al. (1998) observe, however, this is problem faced by all of the major hog exporters in the world.

E. Other Future Issues

Any number of other environmental problems might trigger a greater regulatory role by the government. To pick one example: some evidence indicates that livestock are a significant source of greenhouse gases -- particularly methane. (McCall and Schneider, 1999) An aggressive strategy to reduce these gases may dramatically affect the livestock industry.

F. Future Regulatory Efforts

Some economists are beginning to consider the appropriate level of subsidy to use to encourage farmers to adopt conservation practices, including manure management. These authors tend to argue that not enough is known regarding the proper amount of subsidy. (Cooper and Keim, 1996; Wu and Babcock, 1996; GAO)

Economists are also attempting to analyze the relative costs of environmental regulation of animal agriculture (Goldsmith & Dissart, 1998; Westenbarger & Letson, 1995) For maximum effect, according to one set of economic calculations, cost sharing should target smaller and unregulated operations in vulnerable areas to maximize water quality improvements. (Westenberger & Letson, 1995). Costs for manure management plans, for example, may be significant for dairy and broiler producers. Problems will persist for producers who cannot afford to make necessary improvements in waste management technology or who produce too

much waste to be handled on site.

Economists also tend to support flexibility in regulatory programs. They note, for example, that hog producers vary enough in their circumstances that a variety of policies aiming to affect waste management need to be considered. (Hoag & Roka, 1995) For further discussion on the choice of regulatory instruments, see Keohane et al. (1998) and for a comparison of command and control techniques versus self control see Steinzor (1998).

G. Lessons Learned

A USDA Economic Research Service economist has drawn the following lessons regarding water quality control efforts based. (Ribaudo, 1997)

First, voluntary efforts are more successful when farmers recognize that agriculture contributes to several local or on-farm problems. This suggests that the difficult task of convincing producers that environmental consequences of animal agriculture are real is quite important.

Second, voluntary programs are likely to be successful when the alternative practices generate a higher long-term return. In contrast, therefore, alternatives that are subsidized only briefly are less likely to be attractive to producers. This conclusion certainly increases the cost of any program that seeks to help producers with the costs of an alternative practice.

Third, flexible financial assistance is better than fixed rates and limited lists of supported practices. Both factors seem to be important. For example, the program ideally would allow different producers to receive different assistance even for a practice that is similar on the two farms. In addition, the greater the flexibility in the character of the environmental or conservation practices, the results will be more efficient.

Fourth, education, technical assistance and financial assistance should be coordinated. The author concluded that the assistance program will be more beneficial if it is combined with the full array of government expertise in the area.

Fifth, local research on the economic and physical performance or recommended practices can improve adoption of the practice.

Sixth, voluntary programs are enhanced if backed by firm but flexible regulations.

H Other Ideas -- Paying for Environmental Benefits, Or Taxing Pollution

Critics of regualtion often suggest that a more market-oriented way to obtain environmental benefits ought to be available. There are at least two obvious methods of doing this -- providing a subsidy based on an environmental action by the producer, or taxing the producer who pollutes. (Coleman, 1993)

Some analysts have looked closely at the possibility of making "green payments" to farmers.(Levins & Schmitt, 1995) In theory, this sort of program could include, or could even focus on animal agriculture. On the possibility of tradeoff between environmental gains and

other purposes see Reichelderfer (1990). Green payments were discussed some in preparation for the 1995 Farm Bill. (Knutson & Woods (1995)

Several scholars have examined the idea of using pollution taxes to regulate nonpoint source pollution. (Larson et al., 1996) The tax could be devised so as to funnel the revenue back into a specific agricultural purpose, could exempt certain farmers, and so forth.

In Europe, and in a few instances in the United States, governments have instituted what have been called ecotaxes or pollution taxes. (Gale et al., 1995; O'Riordan, 1997) These have included, for example, the following. The list is largely drawn from Bregha & Moffett (1995).

(1) Taxes meant to correct the "externalities" that result from the cost of pollution on the rest of society. Several Scandinavian countries use this method for emission of sulfur dioxide or nitrogen oxide. For an analysis of how that measurement might take place see Steiner et al. (1995), Bovenberg & Crossen (1995) and Thurman (1995).

(2) User Charges. These are charges that are intended to reflect the true cost of a service.

(3) Subsidies. Financial assistance offered to achieve a certain goal.

(4) Tradable Permits. These are designed to create markets through which business are encouraged to trade pollution rights under a government-set ceiling of total allowable emissions.

I. European Experiments

The Netherlands is a small country with a high population density, 14 million pigs (almost one per person) and 100 million chickens. The Dutch faced, therefore, a number of manure-related problems from their animal agriculture. The Dutch have instituted an system by which they account for the nutrient from the manure and levy producers with surplus manure. (Hotte et al., 1995). Bager & Proost (1997) discuss Dutch farmer compliance

Similarly, in certain areas of the United Kingdom an elaborate system of financial incentives was developed. Farmers receive -- based on a very rough conversion of money -- about $80 to $180 per acre for maintaining the landscape in a certain manner. At the lowest level, for example, it is permissible to graze livestock, but not increase the level of organic fertilizer from animals or other sources over the presently applied amount. At the next highest level, for example, no additional manure may be applied to the soil from confined animals. (Turner & Steele, 1995)

Europe Common Agricultural Policy set up policies that reward farmers for reducing the density of animals per acre. A subsidy is paid and the amount of livestock allowed declines gradually to 2 animal units per hectare. (Soufi & Tuddenman, 1995)

IV. Trade Policies

U.S. trade policy is designed to create a more favorable market for U.S exports. (Knutson et al., 1989; Pasour, 1990) Although this approach has its critics, see for example Wessell (1982), it is a dominant theme in trade policy. For a brief summary of trade policy, see Rosson & Runger (1995) and Sumner (1995).

Economists frequently argue that US agriculture's fortunes depend on selling more product abroad. See, for example, Drabenstott & Barkema (1995). Certainly exports are important for animal agriculture. (Knutson at al., 1998) Meat exports increased significantly in the 1990s. By 1996 beef exports accounted for 7.4 percent of production, pork 5.6 and poultry 16 percent. (Brester et al., 1997) Pork, meat, and turkey exports are also discussed in Haley & Jones (1996), Greene & Southard (1998), Southard (1997), and Harvey and Madison (1996).

(a) Export and Import Policy

The federal government engages in extensive efforts to support U.S. agricultural exports and protect domestic industry from imports. The US has used a number of export promotion program to help develop foreign markets. Export credits and export subsidies have both consumed billions of dollars Drabenstott & Barkema (1995), Le, Kaiser & Tomek (1998). A number of authors explain the workings of these programs. See, for example, Purnell (1991). Export subsidies assist poultry, pork, and dairy products. (Innes, 1995) The most common academic view of export programs is that they are inefficient and should be ended. (Runge et al., 1995; Gardner 1995; Alston et al., 1993)

(b) Free Trade Policy

Economists generally agree that free trade benefits US agriculture. (Hertel, 1996) They also tend to argue that that trade policy should encourage exports and not discourage imports. (Hertel, 1996; Knutson et al., 1989; Raney et al., 1998)

In theory, reduction in trade barriers increase trade, create efficiency gains through specialization and improve income for farmers. (Drabenstott & Barkema, 1995) In many instances, US trade policy has sought to develop a freer trade policy, and bilateral and multilateral trade agreements that promote trade. USDA's trade strategy, in particular, is to open, expand, and maintain global market for trade. (Knutson et al., 1998) Some argue, however, that trade negotiations have compromised export subsidies and other restrictions very little. (Pallbert, 1995)

For a discussion of free trade and environmental issues, see Krissoff et al. (1996).

(c) International Agreements

International agreements play a significant role in trade policy. For a discussion of General Agreement on Trade and Tariffs (GATT) and the World Trade organization (WTO) see Dixit (1996) and Rayner et al. (1993), and for one evaluation of NAFTA see Raney & Shagan (1997).

WTO is a permanent formal international organization that oversees the conduct of trade as agreed to by its members. Its purpose is to liberalize and expand trade through negotiated reduction in trade barriers. WTO is of particular importance for animal agriculture because it is the forum for the meat growth hormone dispute with Europe. (Walker, 1998 ; McNiel, 1998; Mueller, 1996; Blandford, 1990). Biotech and trade regarding labeling and Europe is discussed in Stewart & Jhanson (1999)

The controversial North American Trade Agreement (NAFTA) seems to have affected agriculture exports, including livestock and meat. See Sandler (1992) and Rosson et al. (1993). Trade negations that reduced trade restrictions, including the GATT Uruguay round, the 1989 US-Canadian Tree Trade Agreement, and 1994 North American Free Trade Agreement are given credit by some economists for increasing U.S. agriculture exports. (Brester et al., 1997)

V. Marketing and Demand Expansion Programs

Several USDA programs are designed to improve the producer's position in domestic and foreign markets. (Knutson et al., 1989) Four specific programs especially relevant to animal agriculture are (1) checkoffs, (2) support for cooperatives, (3) grading and reporting by USDA, and (4) marketing orders.

A. Checkoff

Checkoff programs are designed to finance education, market development, advertising and research for a commodity. They exist under special federal statute that authorizes producers to be charged. At present, for example, there are milk, poultry, beef, and other checkoff programs. For a summary of commodity promotion policy, see Armbuster & Nichols (1995) and Forker & Ward (1993). Supporters of these programs believe they can increase demand for goods and increase the political power of the commodity groups in question.

B. Cooperatives

The central role of agricultural cooperatives in animal agriculture would not be possible without special provision in federal and state law that permit and favor these entities. Federal statute waives some aspects of antitrust law for these organizations, and tax laws favor them. (Pedersen & Meyer, 1998; Chen, 1995)

Increasingly, there is criticism from those who believe that cooperatives are not responsive to their membership, especially those cooperatives that have grown very large. Either state or federal government would have the power to force reforms on cooperatives. For a brief

discussion of a dissenter's rights in a cooperative, see Reilly (1994).

C. Grade and Standards, Reporting

The USDA does extensive grading and standards analysis for agricultural goods. It also provides extensive information about prices and marketing. Knutson et al., (1995)

D. Marketing Orders

USDA maintains a complex system of milk marketing orders. (Pedersen & Meyer, 1995; Pasour, 1990; Cropp & Stephensen, 1995) In addition, individual states sometimes make efforts to regulate the price of milk. The United State Supreme court's rejection of some Massachusetts efforts in West Lynn Creamery, Inc. v. Healy are discussed in (Kelley, 1994).

VI. Food Safety

While a large number of food safety policies that affect animal agriculture could be discussed, two stand out for special attention. First, the role of the Food and Drug Administration and other entities in the regulation of biotechnology is discussed. Second, the importance of meat inspection for some producers is discussed.

A. Biotechnology Regulation

In general, biotechnology applications to food production are regulated by the Food and Drug Administration. For a description of the regulation of biotechnology generally, the provisions of the Food, Drug & Cosmetic Act relevant to biotechnology, the FDA regulatory role, related issues of food labeling, and a critical analysis of FDA's role, see Aboulafia (1998). For a similar, though less detailed analysis, see Gendloff (1997). For a general summary of biotech regulation see Hoffman (1988-1989). For the regulation of new life forms -- potentially relevant to animal agriculture -- see Sease (1988-89).

A considerable literature discusses the regulation of bST milk. See, for example, Guarino (1990) and Chen (1995). State level regulation of bST in Wisconsin and Minnesota is discussed in Centner (1995) and Marden (1998), and FDA's role in Aboulafia (1998). Labeling issues are discussed in Dolodinsky et al. (1998).

At least one study suggests that bST is tending to be adopted by larger farms and does increase milk output per cow. It finds, however, no statistically significant increase in farm profitability with bST use. (Stefandides & Tauer, 1999) Some evidence indicates that if bST-produced milk was segmented from non-bST produced milk both bST using producers and non-BST -using producers would benefit when compared to losing milk producers. Further, even if loss of market does not occur, segmenting the market would benefit producers who do not use bST, and may benefit bST users. (Tauer, 1994)

USDA intends to establish an Advisory committee on agricultural biotechnology. (USDA, 1999).

B. Meat Inspection

The requirements of USDA inspection for meat, poultry and eggs are discussed in Harl (1997). For a description of USDA efforts to regulate food safety, and a criticism of the USDA see Casey (1998) and Simon (1998).

VII. Credit Programs

Credit is a crucial aspect in all of agriculture, including animal agriculture. The government is engaged in efforts to makes sure that adequate credit is provided for agriculture at a treasonable cost. (Knutson et al., 1989; Pedersen & Meyer, 1995; Pasour, 1990; Barry, 1995) Credit, especially for family farmers, is often described as in short supply. (Small Farm Commission, 1998; Collender & Kilkove, 1995; Perry, 1998) Even the so-called new and nontraditional lenders are focusing their efforts on large farms. Nenrickesn & Boehlje (1995) Keller (1998) Credit is also subject to booms and busts. (Collender, 1999; Duncan & Taylor, 1993). For a general summary, see Ahrendsen, Barkema & Gusafson (1995)

Although there is significant demand for small-scale borrowers, profit-conscious lenders target larger borrowers, sometimes tend not to provide credit services to small borrowers. . (Duncan, Boehlje, and Lins, 1995) Not all economists, however, agree that credit is in short supply. (Morris & Drabenstott, 1991)

Federal and other programs that aim to assist in lending, are an important source of policy affecting the shape and character of animal agriculture. (Duncan et al., 1995; Credit Programs, Texas A & M, 1995) Two important sources are the Farm Credit System (FCS) and USDA's Farm Service Agency (FSA).

A. Farm Credit System

FCS lenders are federally chartered banks and associations in the Farm Credit System make loans for agricultural purposes to eligible farmer, rancher, and cooperative associations. Federal statute sets out some limitation on the eligibility of borrowers and the relationship between borrower and the institutions. (Pederson & Meyer, 1995; Pasour, 1990; Barry et al., 1993; Boehlje et al.,1995) The farm Credit System (FCS) is granted significant advantages over other lenders in order to further lending to agriculture. FCS lending has been somewhat controversial because of it is thought that FCS is tending to lend aggressively to larger hog operations in the Midwest.

B. Farm Service Agency (FSA) Lending

The Farm Service Agency (FSA) is very active in making loans for family-sized farmers. (Pedersen & Meyer 1995; FLAG, 1990; FLAG, 1999) It is certain that there are many farmers -- including those involved in animal agriculture -- still in business because of these efforts. FSA makes both direct and guaranteed loans. These programs are explicitly targeted for family farmers. They also emphasize beginning farmers. Several important loan servicing options are provided by statute. These include interest reductions for both direct and guaranteed loans, debt restructuring and writedown, loan deferrals.

Unlike virtually every other agency in USDA, therefore, FSA farm loans are targeted to farmers that need the assistance. In contrast, many lenders generally are reluctant to lend to family-sized farms at all. FSA, therefore, tends to function as the lender of last resort for family farmers and as the only credit alternative for many producers. FSA lending has historically been disproportionately to smaller operations. (Dodson & Koening, 1994) Small farms, in fact, are roughly three times as likely for their debt to be from FSA. (Perry) Because of the crisis in hog prices FSA announced a limited moratorium on further lending for additional hog production.

C. Agriculture Mediation

In many states, including Minnesota, agricultural mediation laws influence debtor creditor relationships is a significant way. (FLAG, 1996) Loan mediation is relatively well received in the academic literature. (Knutson et al., 1995)

D. Chapter 12 Bankruptcy

A special chapter of the bankruptcy code addresses the specific problem of family farmers. It has been renewed several times. The consensus is that Chapter 12 has helped producers stay on the land. (Knutson et al., 1995) Most consider the effort to have been a success. (Harl)

VIII. Disaster Assistance and Risk Management

Several federal programs are intended to assist farmers facing natural disaster and to manage the risk of low yields. (Pedersen & Meyer, 1995) For a relatively comprehensive summary of disaster programs, see FLAG (1997) and FLAG (1999 forthcoming). Disaster payments generally are designed for crop farmers. A number of programs over the years, however, have provided some assistance to animal agriculture.

A. Federal Emergency Management Agency (FEMA)

In the case of a disaster, such as a tornado or flood, FEMA can provide assistance to individuals. It is not particularly designed for farmers, and provides little if any benefit during drought.

B. Federal Crop Insurance

Federal Crop Insurance provides subsidized crop insurance. (Knutson et al., 1995; Pedersen & Meyer, 1995; Pasour, 1990; Goodwin & Smith, 1995) As the name suggests, the program is not designed for animal agriculture. A small pilot program, however, includes livestock in an effort to incorporate whole farm planning concepts. (FLAG, 1999) For a brief sense of the concerns expressed by economists in the construction of crop insurance policies -- for example the problem of "moral hazard" -- see Smith & Goodwin (1996), Atwood et al., (1996) The economics of designing crop insurance and other policy issues are discussed in Goodwin & Smith (1995) and Hueth & Furtan (1994), crop insurance literature surveyed in Knight & Coble, and some policy options surveyed in Barnaby et al. (1995). .

An effort to shift crop insurance to an income protection model might make livestock coverage more feasible. If the producer has livestock along with several crops -- that is if the farmer has a diversified farm -- the decision to have livestock in itself reduces risk. A revised crop insurance program might acknowledge the advantage of farm enterprise diversification and include whole farm insurance that includes gains and losses on animals. For one discussion of diversification decisions, see Anosike & Coughenour (1990).

The federal government, through Federal Crop Insurance, plays a significant role in assisting in the management of risk for producers. A large literature describes the various risk management tools available to farmers and examines other alternatives. (Harwood et al., 1999; Schnepf et al., 1999; Mahul, 1999; Goodwin & Ker, 1998)

A recent Federal Crop Insurance reform bill would provide some assistance to livestock producers. Part of the proposed Agricultural Risk Protection Act, it the bill would permit USDA's Risk management Agency to test previously unavailable livestock revenue insurance policies. The livestock insurance pilot program begins with $20 million in fiscal year 2001, increases to $30 million in fiscal year 2002, adds another $10 million in 2003, and increases to $55 million in 2004. Restrictions on how long such programming might take were removed and authorization was allowed for further spending should it be required beyond 2004. The pilot program is limited to new policy approaches and previously unavailable livestock revenue insurance products. USDA will not be allowed to spend any funds to test pilot an insurance product currently commercially available to producers. (House Agriculture Committee 1999)

If Crop Insurance is expended to include livestock, it will be important to make sure that the indirect effects of that insurance are considered. Both traditional Federal Crop Insurance and federal commodity programs have been criticized , for example, for increasing environmental damage. (Wu, 1999; Johnson et al., 1990; Just and Antle, 1990)

C. Non-Insured Crop Disaster Assistance Program (NAP)

The Non-Insured Crop Disaster Assistance Program provides disaster benefits for agricultural corps or other commodities that are not covered by Federal Crop Insurance. The program includes virtually any crop -- but not animal agriculture. (FLAG, 1997; FLAG, 1999 forthcoming)

D. Emergency Conservation Program (ECP)

The Emergency Conservation Program (ECP) provides assistance to help farmers that have suffered from disasters. Livestock producers are eligible for this assistance. It can include, for example, resorting fences, restoring structures an installation, and debris removal after a flood. (FLAG, 1997; FLAG, 1999 forthcoming)

E. Farm Service Agency Emergency Loans and SBA Loans

Farm Service Agency Emergency (EM) Loans are low interest loans (3.75 percent at present) that assist producers who have suffered physical or production losses due to a natural disaster. This program is available for animal agriculture producers. Small Business Administration (SBA) disaster loans are designed for business that suffered disasters. Eligibility for farm business is limited. Nonfarm businesses, such as direct marketing of meat, should be eligible. (FLAG, 1997; FLAG, 1999 forthcoming)

H. Livestock Feed Assistance

Over the last several years, USDA has provided livestock feed assistance during disasters. (Pedersen & Meyer 1995; FLAG, 1997; FLAG, 1999 forthcoming) The amounts of money involved have been relatively small, and the program has a confused statutory and regulatory history. It is one of the few USDA programs, however, that provides a direct benefit to livestock producers.

IX. Tax Policy

Though typically not acknowledged as a farm policy, federal, local, and state taxation policies and US monetary policy have a direct effect on the shape of animal agriculture. Most literature on taxes and agriculture are practical guide for farmers and tax advisers.(Duncan, Koo, and Taylor, 1997) See, for example, Monke (1998) and Davenport & Dunteman (1993). A significant body of evidence, however, suggests that tax policy affects the operation and organization of U.S. agriculture in significant ways. Investment credit, accelerated depreciation allowances, and interest deductibility provisions have promoted capitalization and high debt loads. Special agricultural rules, such as cash accounting and reproduction expenses, have affected the level and mix of farm production. (Carman; Pasour 1990; Parry, 1999)

The resources involved are significant. During the 1970s agricultural tax incentives averaged over $1 billion annually and accounted for almost 25 percent of federal subsidies to agriculture.

Limited partnerships for cattle feeding were one of the most obvious results of this policy. (Carman) Frequently tax policy seems to counteract farm policy. For example, diary policy has sought to control surpluses and maintain higher milk prices. Yet income tax laws effective throughout the middle 1980s provided incentives for dairying and encouraged output. An array of provisions made for powerful incentives to overinvest in dairying.. (Carman) A second example: capital gains rules for livestock can have a dramatic impact on culling and replacement decisions for livestock production. (Carman)

Overall, tax policy seems to have encouraged farm expansion and the reduction in the number of farms. This effect has continued even after the tax reform of 1986. (Carman; Durst & Monke, 1997) With tax policy what appears to benefit individual taxpayers may actually work to their disadvantage when the total response is considered. For example, a capital gains tax exclusion will reduce the short term income for a cattle producer. But as all producer make decision to emphasize capital gains provisions. . . this will increase the breeding herd, and lead to more production and lower prices. (Carman; Monke. 1998)

Three other tax implications are perhaps important. First, the Earned Income Tax Credit, designed to help the working poor, provides significant benefits to low-income farmers, particularly dairy farmers. (Harris 1997); Durst and Monke, 1999)

Second, Congress is considering more preferential treatment of capital gains. (Harl, 1997) Agriculture has been particular susceptible to tax-motivated investment. Investors have been able to deduct costs against other income and in some instance to sell the assets at reduced tax rates. (Harl, 1997) Preferential capital gains tax treatment will affect farmers with breeding and dairy livestock in particular. (Monke, 1998)

Third, many argue that farmers need relief from estate and gift taxes. In fact, the reforms most often discussed would further concentrate ownership of land. Further, it is rarely the case that these problems actually hurt ongoing farm business. More than 95 percent of all farms can be transferred to heirs without any estate tax at all under the existing unified credit. (Harl, 1997)

X. Regulation of Conduct with Animals

State and federal statutes regulate some aspects of the way farmers and others can treat animals. Legally, of course, animals are considered property. For a summary of the way the law considers the possible rights of animals, the provisions of state anti-cruelty laws, the federal Animal Welfare Act, and the Humane Slaughter Act, as well as proposals to strengthen these acts, see Kelch (1998) Cohen (1995), Wise (1998), Wolfson (1996). Relatively limited improvements for animals are discussed in Minert et al. (1995). For a fairly balance discussion of the merits of animal welfare and animal rights claims and how they might be implemented, see Guither & Swanson (1995). In addition, USDA Communicable disease regulatory programs are discussed in Pedersen & Meyer (1998).

XI. Regulation of Contracts and Sales

Contracting is increasing dramatically.. (Banker & Perry, 1999) In a few cases, economists have looked to find the reasons for the increase, but they do little to discuss policy implications of the contracting. See, for example, Hennessy (1996) and McLeay & Zwart (1998). Further, some economists acknowledge that the literature on contracting is limited even though contracts dominate meat production in the sectors of broilers turkey, and to a certain extent hogs. (Tsoulouhas & Vukina, 1999) It follows that literature on policies regulations contracts is also quite limited.

Contract production also is becoming increasingly controversial. The nature of the relationship in poultry production contracts is summarized critically in Fulcher (1992). Some critics have called directly for greater regulation of contracts and of captive supply. (LSP, 1999)

A few states, however, regulate contract production to some extent. See, for example, the legal analysis provided by Hamilton (1994) and Hamilton & Andrews (1993) and the endorsement of the legal strategy by Bahls (1997). Minnesota's provisions are summarized in Welsh (1997)

Were state courts to rule that contract producers are actually employees -- not independent contractors -- the regulation of the agreements would change dramatically. On this distinction see Becker & Haas (1993), Carpenter (1999)

As producers increasingly seek to manage risk through complex legal instruments, problems similar to those with the hedge-to-arrive crop production contacts may arise. This controversy and the role of government regulation in it is discussed in Askelsen (1998), Iavarone (1997), Barrett (1997), and Pedersen (1997).

XII. Corporate Farming Laws

Several states have a form of anti corporate farming law. (Pedersen & Meyer, 1995) For a description of the law in Kansas, see Hamilton (1994), in Missouri, Stout (1996), and in Minnesota, Prim (1996) For a summary and a defense of these efforts, see Bahls (1997). For a legal analysis see Haroldson (1992), Morrisson (1976), Stayton (1991), and Torshynski (1991). For a harsh criticism of these efforts see Chen (1995).

X. Packers and Stockyards Act

Pedersen & Meyer (1995) summarize the background of the Act, the statutory trust for unpaid cash sellers, prompt payment rules, regulations of packer as feedlot operators, the regulation of stockyards, market agencies and dealers, regulations affecting poultry dealers, including prompt payment rules, statutory trust for unpaid sellers. (Looney, 1990; Kelley, 1996)

XI. Disparagement Statutes

For a history of agricultural product disparagement action, the constitutional implications in the such disparagement, and the constitutionality of product disparagement laws, see Hagy (1998) and Bederman et al. (1997)

XII. Labor Law

Agriculture is exempt for a significant portion of labor and employment law. (Pedersen & Meyer, (1998; Harl, 1988) At least to some extent this can include federal minimum wage rules, child labor laws, unemployment compensation, and worker's compensation. For a summary, see Chen (1995), and for more details, see Anderson (1989), (Findeis & Becker) 1995. Similarly, agricultural operations with employees are often regulated at a less comprehensive level than other business under OSHA. (Pedersen & Meyer, 1998)

XIII. Organic and Sustainable Production and Direct Marketing

Organic and sustainable production may become increasingly important for animal agriculture. USDA recently permitted meat to be labeled organic. Organic production has been around for several decades now. Studies, beginning in the late 1970s, have argued that organic production can be competitive with conventional production. (Oelhaf, 1978) One study concludes that many people would pay a premium for pork that was raised in a,n environmentally friendly way. (Hurley & Kliegenstein, 1999) Whether this is literally true or not, organic production continues to grow yearly. (Duram, 1998)

For a summary of organic food certification at the state level see Bones (1990). Organic labeling is discussed in legal terms by Centner & Lathrop (1996), Vaupel (1997) , and Clark (1995).

However one defines sustainable agriculture, the general consensus is that its practice in the upper Midwest will involve livestock and diversified farming. (Roberts & Hollander 1997; Duram 1997; Burkhardt 1992; Delind, 1991; Exner & Thomson, 1990; Murphy, 1990; Caneff 1993)

A growing body of writing addresses the feasibility of an alternative, sustainable method of pork production. (Ziegenhorn, 1999; Honeyman, 1996; Furuseth, 1997) Policies that affect the prospects of organic and sustainable livestock production are therefore likely important for an increasing number of poultry and livestock producers. For a sociological and an economic analysis of the differences between conventional and alternative agriculture see Beus & Dunlap (1990) and Curry-Roper (1992). Some scholars are now developing an analysis to measure the extent to which a producer is farming sustainably. (Beus & Dunlap,1991; Capalbo & Antoel, 1998; Herdt & Steiner, 1995)

Farmers' markets are important to some producers, and increasing possible for livestock

producers. (Lyson et al., 1995). Journalistic accounts suggest that direct marketing of sustainable or organic production is a viable alternative for some producers. (Devore, 1999). Extension research and sociological studies suggest the same possibility. (Field Notes, 1999; Welsh, 1997)

Efforts to promote sustainable animal agriculture might focus on the following areas. Schaller (1998) and Vasavada et al. (1997) suggest some of these. For further suggestions, see Flora (1990) and Youngberg et al. (1993). In addition, Pierce (1992) suggest a way to think about a policy agenda for sustainable agriculture.

(1) Research and Education. Only a small fraction of research funds go to sustainable agriculture at present. Hoag et al., (1995) Included in the research might be effort to better understand what the largest adoption difficulties were and how they can be addressed. Salamon et al.

(2) Financial Incentives. Cost-sharing for the development of certain practices might be effective. Green payments for certain practices may also be practical.(Carriker & Abdalla, 1995)

(3) Revise Crop Insurance. Crop insurance could be made to cover livestock and poultry and thus recognize the diversification of risk that takes place on a sustainable farm.

(4) Ensure Credit for Family-Based Livestock Production. Credit is an especially difficult problem for sustainable farmers. (Gebremedhim & Christy, 1998)

(5) Support Direct Marketing. USDA could make more of an effort to assist people in developing direct markets. Direct marketing can, according to some, serve as a generator or rural development. (Gale vol 12)

(6) Force Nonsustainable Producers to Internalize Environmental Costs.

Question 2b: How, and to what extent do the government actions and policies catalogued in question 2a. affect animal agriculture relating to economics, profitability, size and location?

As stated above, the results of the literature review in answer to all of the Role of Government questions on the effectiveness of policies and programs were small. The discussion below describes the articles that were reviewed. Again, a focus for further research in the area of Role of Government should be to document outcomes and effectiveness rather than new policy options.

Structural changes in the livestock industry (driven by economic and social forces, but in conflict with traditional views of agriculture) combined with highly publicized incidents of discharge from manure storage facilities into surface water are focusing attention on environmental and nuisance concerns arising from the concentrated production of livestock. Animal agriculture is industrializing, characterized by fewer farms with more animals per farm producing an increasing share of meat, milk and eggs for American and global consumers. This concentration of animals is perceived by much of the public to create greater pollution and nuisance risk. Many also feel that these negatives tend to increase as size and density of production units increase. According to the U.S. Environmental Protection Agency (EPA) concentrated animal feeding operations (CAFOs's) are responsible for 26% of the surface water impairments caused by agricultural pollution. (Glover, 1995)

Concentration of animal agriculture has encouraged all levels of government to attempt to resolve concerns through public policy. Federal policy has come from the Environmental Protection Agency through the Clean Water Act (CWA) and National pollutant Discharge Elimination System permits. The Coastal Zone Act Reauthorization Amendments focus on nonpoint discharges in 29 coastal and Great Lakes states, including Minnesota, and are more stringent than the CWA. The 1996 farm bill (called The Federal Agriculture Improvement and Reform (FAIR) Act) created an Environmental Quality Incentives Program (EQIP) where 50% of the funds are earmarked for manure management by livestock producers.

States have the authority to write and enforce policies more stringent than federal policy. The most common state policy has been the corporate farming laws and the right-to-farm laws. Corporate farming laws, which are anti-corporate farming in intent, attempt to protect small, mid and family owned and operated farms.

Minnesota government has taken more aggressive action in attempting to reduce the negative impact of animal agriculture. The Minnesota Pollution Control Agency (MPCA) has the primary responsibility for the state's regulation of animal agriculture through a state permitting process. County government has entered into policy making in recent years by taking on the permitting process through delegation from the MPCA and by enacting local feedlot zoning ordinances. The belief is that increased local control and enforcement of policy will result in a greater level of responsiveness and satisfaction from both producers and other citizens. Counties have utilized

zoning and feedlot ordinances in response to pubic concern. Also, as local township governments become unhappy with county control, some townships will develop ordinances and other policies as a means of controlling animal agriculture in their community.

As the role of regulation has moved to the most local governmental units there is a perception that the level of conflict between livestock producers and their non-animal producing neighbors has increased. However, it is also likely that, concurrently, concentration and public awareness has increased and is contributing to the increased conflict.

The arguments for greater local control include greater familiarity with issues and situations, more citizen input, greater responsiveness, and shorter response times. Dangers are that local politics, individual pressures and biases; lack of skilled staff and reactionary citizen involvement can replace policy based on sounder fundamentals.

The opportunity for more local governments to capitalize on the potential strengths listed above is also potentially offset by the increased ability of strong interest groups (whether producer interest groups or anti-livestock citizen organizations) to apply political pressure in local political environments. Disputes tend to be more personal in the local setting and feedlot issues polarize numerous rural communities. The location where conflicts are resolved has in some instances moved to the courts. (Glover 1996)

How the role of government has affected the economics, profitability, size and location of animal agriculture is difficult to ascertain. Much of the research and writings are very recent and are based on opinion as well as sound data. Most literature is found in working papers within land-grant universities and in surveys of perceptions of impact.

Many factors influence hog industry location in the U.S. including technology and institutional change. The industry is now less tied to natural resources and more mobile. There is anecdotal evidence supporting the hypothesis that stringency of state environmental regulations influences firm's location choices. Mo and Abdalla (1998) attempted to determine the effect of stringency of regulations on industry locational choices. Hog industry growth in 13 major hog producing states was measured from 1988/89 to 1994/95. The effects of 17 characteristics/ factors were studied. The factors were grouped in 4 categories; natural endowment, economic factors, business climate, and regulatory factors.

Regulatory factors included stringency of regulation (determined by survey), average amount of the fines imposed, annual staffing levels of enforcing agency, presence of anti-corporate farm law, and presence of local zoning ordinances. A linear model was used to estimate the relationship between industry growth rate and all other variables.

In summary, the results for the environmental regulatory variables were mixed. Stringency of regulation was insignificant in three models. Possibly, lack of variation between states contributed to this lack of measured impact. The presence of an anti-corporate farm law was

insignificant in the one model where it was tested. The presence of local zoning ordinances was tested in two models and was significantly associated with reduced growth. The level of staffing was found to be unexpectedly positively related to growth in swine numbers. Possible industry growth stimulated the increased staffing rather than increased staffing reducing growth. Size of fines levied was tested in one model and found to be significantly associated with lowered production growth.

From an overall standpoint, the results did not strongly support the hypothesis that stringency of environmental regulations impacted hog inventory growth over the study period.
Metcalfe (1999), examines the effect of increasing environmental regulation on the location of hog production in the U.S. domestic and international markets. Agricultural pollution from concentrated animal feeding operations is becoming a major environmental consideration in the heavy hog production regions of Northern Europe as well as in the high production areas of the United States. As environmental concerns increase and governmental regulations are imposed to protect the environmental quality in these areas, will there be a shift in production signaling an increase in competitiveness for regions with more lax environmental regulatory standards? This is an important question for U.S. hog producers from both a domestic (interstate) and an international perspective.

The first half of this study examines differences in state water quality regulations and their influence on the location of hog production in the United States. Modeling the profit maximization decision of hog producers allows investigation as to whether or not the current changes in the industry towards larger and more geographically concentrated operations has been influenced by environmental regulation. This analysis is conducted separately on small and large operations as this allows for the examination of the potential differences in the regulatory effect by size of operation.

Results suggest greater environmental regulatory stringency has no significant effect on the location of hog production. The amount of hog production occurring on small operations seems most responsive to differences in the traditional input and transportation costs, while production on larger operations is being drawn to states with existing transportation and agricultural infrastructure.

The second half of the study examines differences in international regulation and the possible effects on the competitiveness of the pork exporting industry. Information on the environmental regulation affecting CAFOs in the major exporting countries is presented. The methodology for the empirical analysis in this study is still being developed. Therefore, Part II of this paper is an attempt at defining competitiveness and identifying the factors that make a country more or less competitive in the international pork market. An empirical model is then proposed in an attempt to move the debate away from a comparison of stylized facts and into an econometric framework. There are no results at this time.

Two reviews of state level legislation used to control animal agriculture are summarized below. The observations in these reviews may give some guidance to Minnesota policy-makers.

Leatham et al.(1992) used a dairy waste management spreadsheet, developed and applied along with partial budgets and whole firm, Monte Carlo simulations for Texas dairies to evaluate the impact that Texas water quality laws have on dairy profitability and survival. Results showed that representative 300- and 720-cow dairies will incur additional annual costs of $60 and $81 per cow, respectively. Compliance with water quality laws reduces net farm income by 27% and 63% for 720-cow dairies with low and high debt positions, respectively. The probability of survival of the dairies with low debt was not affected by compliance. The probability of survival of firms with high debt positions decreased by 47 percentage points. Under the conditions modeled, net farm income for representative 300-cow dairies would be negative after compliance with water quality laws. .

Environmental issues such as air and water quality related to livestock production currently receive much attention. Potential methods for environmental improvement range from regulation to market solutions. If environmental policies require producers to produce livestock in a more "organic way" with limited current technology, are consumers willing to pay the extra cost of the food product.

The State of Illinois approved the Livestock Management Facilities Act (LMFA) in May 1996. The LMFA provides an excellent case study in the regulation of large-scale swine production, in particular regulatory options available in the handling, storing and disposing of livestock waste. St. John (1996) analyzes the following key sections of the LMFA in the context of the larger debate concerning the appropriate type and degree of regulation necessary for such facilities.

- Site Definition & Setbacks
- Lagoon Design & Construction
- Manure Management Plan
- Facility Closure
- Indemnity Fund
- Local Control
- Checks & Balances
- Liability for Environmental Damage

The paper concludes with the observation that the 1996 LMFA is ineffective in regulating the design, location, construction, and operation of large-scale swine production facilities in Illinois because the drafters of the bill were unable or unwilling to learn from the prior experience of other states in regulating such facilities.

Commenting on the same piece of legislation as St. John (LMFA), Goetsch and Beaver (1998) state that immediately after the Act was passed, interest groups continued to point out potential weaknesses in the new law, even before it could be completely implemented. The debate continued throughout the original rulemaking process and into the 1997 fall veto session of the

legislature. The final result was an amendment to the LMFA which further expanded the state inspection requirements of new or proposed lagoons; added public informational meetings for proposed lagoons; and added setback distances for dead animal composting sites and several other requirements. The debate continues, according to Goetsch and Beaver, as to whether the amended Act adequately addresses all components of livestock production and livestock waste management.

One final study that relates peripherally to policies that encourage sustainable or organic production methods for animal agriculture is found in Hurley and Kliebenstein (1999). They looked at consumer willingness to pay for pork products with embedded environmental attributes "organic pork". This study was conducted using an "auction" method where people made choices to spend their own dollars to purchase organic pork. Specifically the environmental improvements in this study were related to a reduction in livestock odor and surface and ground water impacts through swine manure storage and application methods. Experimental auctions showed that over one-half of the participants (62%) paid a premium, that did not vary significantly between six regions of the United States, both rural and urban settings.

Question 3: How are public funds for animal agriculture research, education and training currently allocated in Minnesota and how does the allocation of these funds impact the development of animal agriculture and Minnesota citizens as a whole?

To conduct the literature review, Question 3 was divided into two parts. Researchers on Questions 3a. searched for literature that documented how public funds for animal agriculture research, education and training currently are allocated in Minnesota. Researchers on Question 3b. focused on literature about how the allocation of funds impacts the development of animal agriculture and Minnesota citizens as a whole.

There are relatively few pieces of literature that address Question 3a. or 3b. In answer to Question 3a., the researchers did compile information about public funds for animal agriculture that are received by the University of Minnesota. Some information about other federal funds allocated to research on animal agriculture in Minnesota has also been compiled. In answer to Question 3b., no literature that addressed the impact of the allocation of funds on Minnesota was found. There were some documents that addressed the impact of fund allocations at a national level. These documents are summarized in this report.

Based on the results of the literature review, and data gathering, the literature review on Question 3. has been divided into three sections:

- Funds Allocated to the University of Minnesota College of Agricultural, Food, and Environmental Sciences
- Federal Funds Allocated to Other Research in Minnesota
- National Level Research Investment With an Emphasis on Research in Animal Science

Funds Allocated to the University of Minnesota College of Agricultural, Food, and Environmental Sciences

The University of Minnesota is the Land Grant College in Minnesota. The land-grant system was launched more than a century ago and has included research and Extension as basic components of a partnership between the land-grant universities across the nation and the Cooperative States, Research, Education, and Extension Service (CSREES)
in the United States Department of Agriculture. Fundamental to land-grant universities is a focus on the agriculture and related issues of the state through research, teaching, and extension.

Most land grant universities, including the University of Minnesota, have an Agricultural (AES) Experiment Station and an Extension Service. The Minnesota Agricultural Experiment Station (MAES) and the University of Minnesota Extension Service (UMES) receiving funding from Federal Government and the state of Minnesota. Federal formula funds as distributed to the AES in each state/territory (e.g., Hatch, McIntire-Stennis, Animal Health, and Multi-State Research). These funds provide for the basic infrastructure needed for agricultural research in each state. In Minnesota, these funds are combined with state funds.

The Minnesota Agricultural Experiment Station provides funding for five colleges: The College of Agricultural, Food, and Environmental Sciences; The College of Veterinary Medicine; The College of Human Ecology; The College of Natural Resources; and The College of Biology Sciences. The University of Minnesota Extension Services provides funding for the five Colleges mentioned above and to countries for support of county based extension programs.

The Colleges of Human Ecology, Natural Resources, and Biology Sciences do not conduct research, teaching, or extension in animal agriculture, and thus will not be included in this literature review.

The College of Agricultural, Food, and Environmental Sciences receives 70% and the College of Veterinary Medicine receives 5% of the overall funding available to MAES. The College of Agricultural, Food, and Environmental Sciences receives approximately 56% and the College of Veterinary Medicine receives approximately 8% of the overall funding available to the University of Minnesota Extension Service.

The mission of the College of Veterinary Medicine is to advance the practice of veterinary medicine, to foster the welfare of people by contributing to animal health care and performance, and to contribute to enhancing human health through teaching, research, and service. The College of Veterinary Medicine consists of four budgeted areas: the Department of Clinical and Population Sciences; the Department of Small Animal Clinical Science; the Department of Veterinary Diagnostic Medicine; and Administration.

The College of Agricultural, Food, and Environmental Sciences (COAFES) encompasses responsibilities for research, education, and outreach related to the production and use of biological materials for society's needs, and related to the interactions of these products and processes with people and the environment. More explicitly, the mission is to provide responsible leadership in the generation and application of research-based knowledge to the use of our natural and human resources for the production, distribution, and consumption of food, fiber and renewable energy, and for the betterment of our natural and human environments--all with technologies that address needs and concerns of a diverse constituency.

In total, COAFES supports 245 faculty, 435 support staff and 175 professional academic staff. The College enrolls 917 undergraduates and 358 graduate students. The college's research and outreach missions are supported in part by the Minnesota Agricultural Experiment Station (MAES) and the University of Minnesota Extension Service (Extension). Most faculty and many support staff have joint appointments with the MAES and Extension.

Reflecting its land grant roots, the College's tripartite mission is supported on a recurring basis by University O&M funds, state special and federal formula funds, as well as grants and gifts. State and federal funds are provided by cooperative agreements in support of research and outreach in agriculture. The College administers and supports extensive off-campus research facilities, including Research and Outreach Centers (Experiment Stations) throughout the state.

The College of Agricultural, Food, and Environmental Sciences consists of twenty-one budgeted areas as listed below.

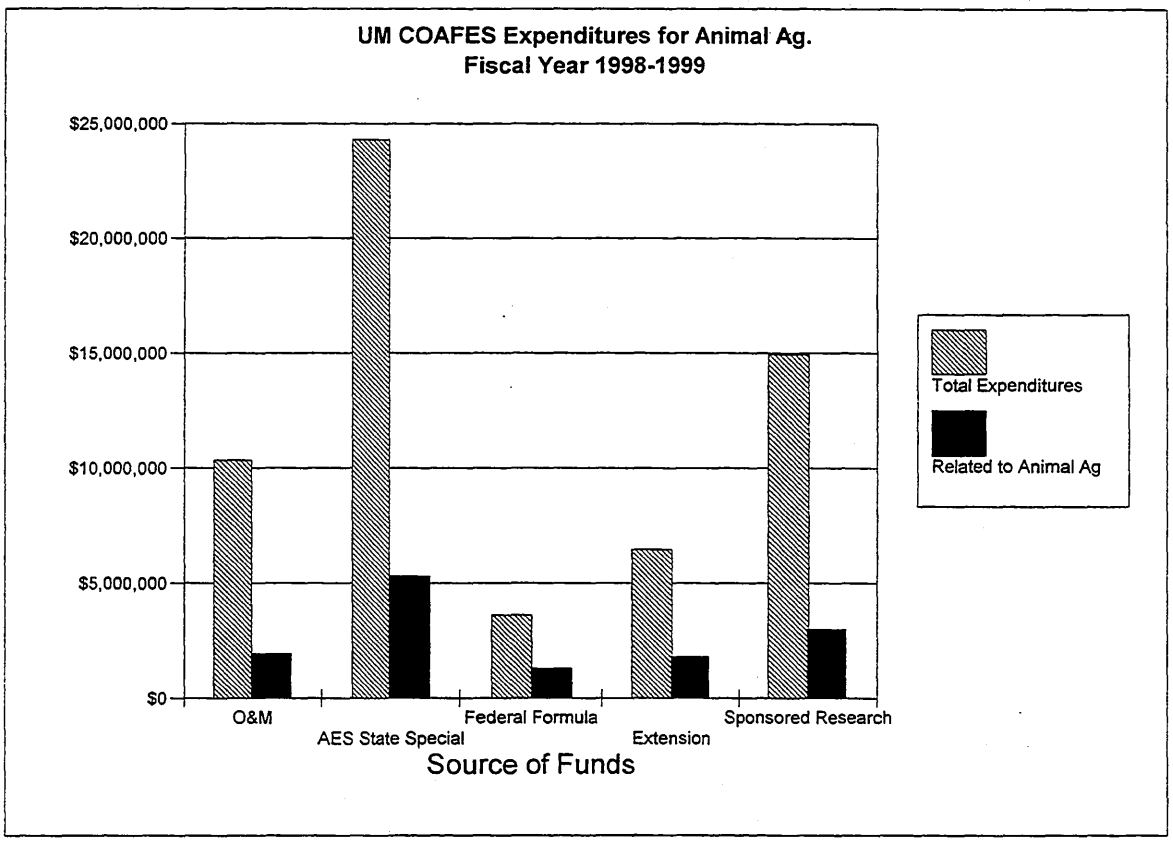
COLLEGE OF AGRICULTURAL, FOOD, AND ENVIRONMENTAL SCIENCES (COAFES)

Department of Applied Economics
Department of Agronomy & Plant Genetics
Department of Animal Science
Department of Biosystems and Agricultural Engineering
Department of Entomology
Department of Food Science & Nutrition (Agr)
Department of Horticultural Science
Department of Plant Pathology
Department of Rhetoric
Department of Soil, Water, & Climate
Agr/food/envrn Sci, Coll-adm
International Agriculture Programs
Landscape Arboretum
Agricultural, Food, and Environmental Education Division
Student Services
Southern Research and Outreach Center - Waseca
Southwest Research and Outreach Center - Lamberton
Westcentral Research and Outreach Center - Morris
Northwest Research and Outreach Center - Crookston
Northcentral Research and Outreach Center - Grand Rapids
Research and Outreach Center - Rosemount

The College of Agricultural, Food, and Environmental Sciences receives funding from five sources: Agricultural State Special (State Funding); O & M Funding (State Funding); Extension (State Funding); Federal Formula funds; and Grants and Contracts (Sponsored Research). The research team was unable to find literature addressing the question of how public funds for animal agriculture are currently allocated in Minnesota for research, education and training. The research team did, however, compile the following information that was available through the budgeting office of the College to address the question.

Graph 1, on the following page, shows the sources of funding as a percent of the total College budget for 1998-99.

Graph 1

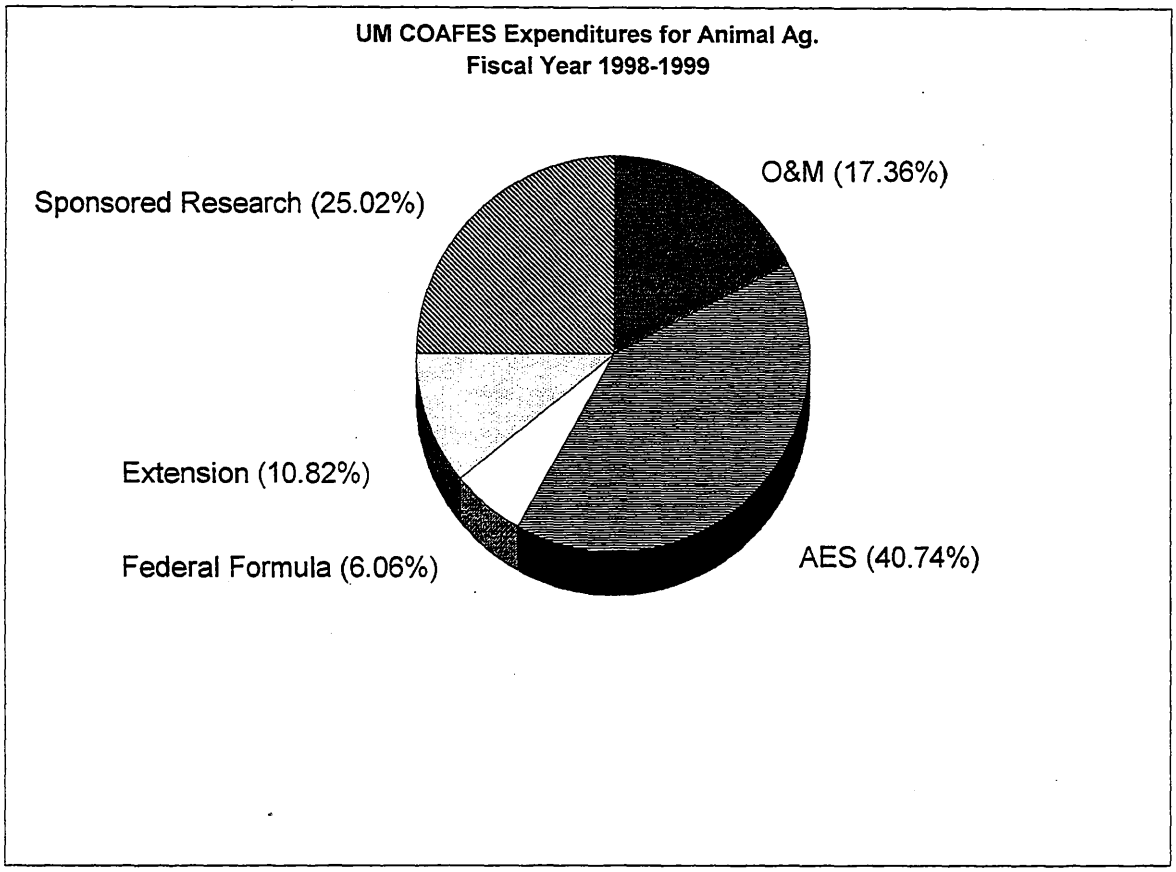


Source: data compiled by COAFES

Expenditures in COAFES for animal agriculture primary occur in the Department of Animal Sciences and at the six Research and Outreach Centers. However, faculty in the Departments of Soil, Water, and Climate; Agronomy and Plant Genetics; Biosystems and Agricultural Engineering; Applied Economics; and Entomology conduct research, teaching, and outreach in support of animal agriculture in Minnesota.

Graph 2, below, shows the animal agriculture related expenditure in percent compared to total expenditures by category for 1998-99 for COAFES. On the average, 25% of all expenditure in the COAFES where related to animal agriculture in 1998-99.

Graph 2



Source: data compiled by COAFES

Table 1, below, shows the funding by species of animals in the Department of Animal Science from 1998 to 2000. Funding for animal research has remained fairly constant. Table 1 lists the level of funding by species by several categories. Hatch funding is federal funding, RRF is federal funding, GAR is state of Minnesota funding, MES is state of Minnesota funding, O & M is state of Minnesota funding, and other refers to funding from grants and contracts received by faculty.

Table 1

UM Department of Animal Science Funding by Species 1998-2000

1998	Hatch	RRF	GAR	MES	O&M	Other*	TOTAL
Beef	$0	$0	$130,722	$71,629	$24,907	$73,581	$300,839
Dairy	$22,934	$77,057	$403,659	$245,300	$267,516	$744,317	$1,760,783
Hogs	$201,021	$28,080	$600,961	$82,549	$252,913	$383,810	$1,549,334
Poultry	$173,914	$139,401	$346,823	$80,131	$85,129	$667,186	$1,492,584
Other**	$0	$0	$648,282	$408,744	$484,044	$252,796	$1,793,866
TOTAL	**$397,869**	**$244,538**	**$2,130,447**	**$888,353**	**$1,114,509**	**$2,121,690**	**$6,897,406**
1999							
Beef	$0	$0	$110,757	$80,541	$32,056	$51,746	$275,100
Dairy	$21,934	$77,057	$441,626	$260,256	$360,311	$763,123	$1,924,307
Hogs	$201,021	$28,080	$577,875	$95,386	$306,226	$355,252	$1,563,840
Poultry	$214,039	$139,401	$381,774	$58,645	$77,978	$1,195,803	$2,067,640
Other**	$1,000	$0	$642,484	$365,215	$334,412	$58,794	$1,401,905
TOTAL	**$437,994**	**$244,538**	**$2,154,516**	**$860,043**	**$1,110,983**	**$2,424,718**	**$7,232,792**
2000							
Beef	$0	$0	$120,673	$81,431	$32,702	$51,311	$286,117
Dairy	$27,609	$53,033	$435,676	$183,024	$373,008	$663,952	$1,736,302
Hogs	$196,968	$28,080	$528,491	$98,715	$302,285	$308,714	$1,463,253
Poultry	$209,975	$163,425	$333,820	$60,211	$80,416	$1,107,051	$1,954,898
Other**	$19,608	$0	$723,721	$290,665	$329,220	$25,047	$1,388,261
TOTAL	**$454,160**	**$244,538**	**$2,142,381**	**$714,046**	**$1,117,631**	**$2,156,075**	**$6,828,831**

* includes funding from private and federal agencies
** includes administrative costs and research done on a variety of other species

source: data compiled by COAFES

Table 2, on the following page, is a summary of Agricultural Experiment Stations projects for FY2000 in the Department of Animal Science. Projects are listed by title, lead principle investigator, species and funding source. All researchers receiving federal and state funding must develop an Experiment Station Project. These projects are "peer reviewed" every five years.

FY 2000 Recap Project Summary Table – Animal Science

Project	Title	Lead PI	Species	Hatch	MRF	GAR	EXT	OM	Other	Grand Total
16-044	Factors Affecting Biological And Economic Efficiency of the Beef Cattle Enterprise	DiCostanzo	B			64,435	51,881	32,702	51,311	200,329
16-028	Genetic Enhancement of Health & Survival for Dairy Cattle	Hansen	D		28,109	66,568		149,109	13,595	257,381
16-042	Genetic Improvement of Cattle Using Molecular Genetic Information	Crooker	D							
16-046	Regulation of Nutrient Use in Food Producing Animals	Crooker	D	26,609		73,423		37,671	372,092	509,795
16-047	Feeding Management And Utilization of Nutrients by Dairy Cattle	Linn	D			122,345	68,386	69,865	195,014	455,610
16-048	Methods for Achieving Optimal Protein Utilization In Ruminants	Stern	D			56,278		50,389	28,654	135,321
16-050	Metabolic Relationships in Supply of Nutrients for Lactating Cows	Stern	D		24,924	9,188				34,112
16-072	Factors Affecting the Success of Bovine In Vitro Fertilization	Hunter	D	1,000		83,189		58,593	17,793	160,575
16-024	Nutritional Determinants of Cardiovascular Disease	Osborn	H			108,364		42,913		151,277
16-060	Nutritional, Physiological, and Developmental Regulation of Factors Affecting Swine Growth	White	H			117,765		29,303	101,315	248,383
16-064	Evaluation of New Nutritional Technologies for Situation Dependent Diet Formulation in Swine	Shurson	H	115,122		114,838	28,995	69,305	62,003	390,263
16-080	The Effect of Growth Factors on the Processes of Skeletal Muscle Growth in Meat-Producing Animals	Hathaway	H	21,376		59,788		41,333	18,064	140,921
16-084	Molecular Mechanisms Regulating Skeletal Muscle Growth and Differentiation	Dayton	H		28,080	103,203		14,023	123,565	268,871
16-017	Advanced Technologies For the Genetic Improvement of Poultry	Foster	P		35,639	90,596		30,588	48,229	205,052
16-023	Establishment Of a Chicken Radiation Hybrid Panel for Fine Genetic Mapping	Ponce de León	P	37,653		36,087			379,199	452,939
16-034	Improving Turkey Production Performance	Noll	P	83,001		36,979	60,211	3,499	92,405	276,095
16-087	Reproductive Performance of Turkeys	El Halawani	P	53,885	127,786	138,784		46,329	587,218	954,002
16-G01	Genetic Events That Control the Length of the Cell Cycle	Foster	P							
16-G02	Modulation of Reproductive Efficiency by Prolactin in the Domestic Turkey	El Halawani	P							
16-G03	11th North American Colloquium on Domestic Animal Cytogenetics and Gene Mapping	Ponce de León	P							
16-073	Reproductive Performance in Domestic Ruminants	Wheaton	O							
16-075	Hormonal Control, Enhancement and Diagnosis of Ovarian Function in Farm Animals	Wheaton	O			92,640		38,326		130,966
16-082	Mechanisms of Ion Transport Across Porcine Endometrium	O'Grady	O			81,894		56,970	13,034	151,898
16-014	Research Operations		O*	115,154		686,017	249,972	223,195	17,239	1,291,577
16-X01	Non-AES Employees		O**				254,601	123,718	35,345	413,664
Dept. Summary				**454,160**	**244,538**	**2,142,381**	**714,046**	**1,117,831**	**2,156,075**	**6,829,031**

B = Beef; D = Dairy; H = Hogs; P = Poultry; O = Other.

*Project 14 includes funding for all categories and includes Administration (see Funding by Species for actual category dollars).

**Non-AES includes funding for Dairy, Hogs, and Other categories (see Funding by Species for actual category dollars).

The COAFES maintains research and teaching animal herds at five of the six Research and Outreach Centers and at the St. Paul Campus. Table 3 below is a summary of species type at each site.

Table 3

Summary of Species Types at Research at UM Outreach Centers and St. Paul Campus

Location	Beef	Cow/Calf	Dairy	Swine	Poultry
St. Paul	X	X	X	X	X
SROC - Waseca			X	X	
WCROC - Morris			X	X	
NWROC - Crookston		X	X		
NCROC – Grand Rapids		X			
ROSEMOUNT				X	X

Source: compiled by COAFES

Federal Funds Allocated to Other Research

The Federal Government provides funding for animal agriculture through the Agricultural Research Service (ARS) and the USDA Cooperative State Research, Education and Extension Service. Table 3 below is a summary of ARS funding for all programs nation-wide from 1998 to 2000. Approximately 16% of ARS funding is used for animal agriculture research.

Table 3

AGRICULTURAL RESEARCH SERVICE (ARS)
Program Level
(Dollars in Millions)

Program	1998 Actual	1999 Current Estimate	2000 Budget
Research and Information:			
1. Soil, Water and Air Science	$84	$86	$108
2. Plant Science	253	275	278
3. Animal Science	120	127	131
4. Commodity Conversion & Delivery	148	162	160
5. Human Nutrition	70	68	89
6. Integration of Agricultural Systems	28	30	31
7. Information & Library Services	20	19	21
8. Repair and Maintenance	18	18	18
9. Contingency Research Fund	1	1	1
Total, Ongoing Research & Info	**742**	**786**	**837**
Supplemental Drug Control Research			
1. Funding	000	28	000
Total, Research & Info & Supp	**742**	**814**	**837**
Trust Funds	20	20	20
Buildings and Facilities	81	56	44
Total, ARS	**$843**	**$890**	**$901**

Source: data compiled by COAFES

Table 4 is a summary of USDA funding for all programs from 1996 to 2000.

Table 4

USDA COOPERATIVE STATE RESEARCH, EDUCATION & EXTENSION SERVICE
Information Summary

USDA-CSREES Budget Summary

Selected Items:	**Budget ($ Million)**			
	FY 96	**FY97**	**Prop.**	**FY98**
Hatch Act Funds	168.734	168.734	168.734	168.734
Animal Health (1433)	5.051	4.775	4.775	4.775
Rangeland Research Grants	0.475	0.475	------	------
Special Grants	59.615	61.536	34.789	67.743
Evans Allen (1890)	27.735	27.735	27.735	27.735
Aquaculture Centers	4.000	4.000	4.000	4.000
Sustainable Agriculture	8.100	8.000	8.000	8.000
Federal Adm. Grants	10.337	10.249	2.662	11.226
Buildings & Facilities	57.838	61.591	------	------
Higher Education	19.500	20.150	20.500	21.500
Extension	427.750	426.273	417.8	423.376
McIntire-Stennis (Coop. Forestry)	20.497	20.497	20.497	20.497
National Research Initiative (NRI):				
Animal Systems	23.750	23.104	29.500	24.000
Plant Systems	37.000	36.044	47.000	37.000
Nutrition, Food Safety & Health	7.400	7.209	11.000	8.000
Natural Resources & Envir.	17.650	17.194	27.000	17.500
Markets, Trade & Policy	4.000	3.897	6.500	3.900
Processes and New Products	6.935	6.755	9.000	6.800
Water Quality	------	------	------	------
Integrated Pest Management	------	------	------	------
Pesticide Impact Assessment	------	------	------	------
Total – NRI	**96.735**	**94.203**	**130.000**	**97.200**

Source: Information compiled by Richard R. Frahm, National Program Leader Animal Genetics, USDA-CSREES

National Level Research Investment With an Emphasis on Research in Animal Science

The available estimates of investments in and returns on animal science research and extension for U.S. agriculture are at the national level. No studies of the rate of return on animal research have been conducted for the state of Minnesota. This discussion begins with an overview of public and private research investments for all segments of U.S. agriculture. The discussion moves to funding for livestock and poultry research and rates of return to animal research in the U.S. The following comments are based on unpublished tables from Alston, Christian and Pardey and Fuglie, Narrod and Neumyer. (Alston et al. 1999) (Fuglie et al. 1999) The tables are included with permission of the authors and are found at the end of this section.

Funding of Animal Research

Table 5 shows the sources of funds (in both nominal and 1993 dollars) for state agricultural experiment stations (SAES) and other cooperating institutions for the period 1972 through 1997. Nominal dollars of SAES funding increased dramatically over the period. Even after being deflated, expenditures increased approximately 66 percent (in 1993 dollars) over this period. However, the average annual growth rate of every source of SAES funding listed in Table 5 declined in the 1990s, and the total declined in real terms after 1994.

As shown in Table 6, the proportion of total expenditures on agricultural research provided by USDA declined over the period, while the proportion provided by the private sector increased. USDA funding for agricultural research has increased less rapidly than SAES over the period, making SAES funding a larger proportion of total public research. The proportion of public research funding provided by SAES increased from 65% in the 1970s to 77% in 1997. Private research funding, approximately equal to public research in the 1970s, grew more rapidly over the period. As a result, the ratio of public research to private research declined from 1.01 in the 1970s to 0.76 in 1997.

The percentage of SAES funding devoted to crops and livestock declined from 1970 to 1993, as shown in Table 7. Research funding for livestock as a percentage of SAES funds declined from 26.3% in 1970 to 23.3% in 1990. The percentage declined for all species of livestock and poultry except swine, which was approximately the same in 1993 as it was in 1970. The research areas receiving increased funding over the period include natural and recreational resources, trees, forest and forest products, fish and game, and other.

Research expenditures relative to commodity value is referred to as research intensity. The research intensity for livestock and poultry in 1970, 1984 and 1996 is given in Table 8. The public sector research intensity has declined for layers, broilers, and turkeys, while beef, dairy and swine increased. The research intensity for sheep and wool has increased more dramatically than for other species because research expenditures for sheep have increased substantially while increases in production value have been modest even in nominal terms.

Table 9 documents the public sector animal research by sources of funds in both dollar value and percent of total expenditures. The animal research is differentiated by species and compares three discreet years of expenditures in 1996 dollars.

Rates of Return on Animal Research

Successful investment in agricultural research leads to increases in productivity, that is more output from a given amount of total inputs. Increases in productivity stem from the development of new or improved outputs, better or cheaper inputs, and other changes in the stock of useful knowledge that enables producers to choose and combine inputs more effectively.

Evaluations of the economic effects of research involve relationships between the size of the investment in research and the increased output. These evaluations account for the timing of research investments and the economic benefits, since there are often lengthy lags between the initiation of the research, the adoption of research results, and the realization of benefits.

A large number of studies have estimated the rate of return on livestock and poultry research in the U. S.. These studies, conducted using a variety of methodologies, report relatively high social rates of returns to society. The studies summarized in Table 10 have returns of 21 percent or more, indicating that research in animal agriculture is a good investment. Work by Huffman and Evenson (1993) suggests the payoff for pretechnology (basic science) livestock research is much greater than for applied research. There has been no definitive work for the period after 1982 although ad hoc work has suggested some decline in the return to animal research. One of the reasons given is the redundancy of some animal research conducted in multiple locations when a couple of locations would have sufficed. However, more work is needed to verify this hypothesis.

The social rates of return discussed in this paper are based on data for the entire country. An evaluation of the returns to animal research and extension investments in Minnesota would require a new study.

TABLE 5 - ce of funds for state agricultural experimental stations (SA and other cooperating institutions

Year	Federal				Non-Federal					Grand Total	
	CSREES Admin	USDA[b]	Other[c]	Total	State	Sales	Industry[d]	Other	Total	Nominal	Real[f]
	(millions U.S. dollars)							(millions 1993 U.S. dollars)			
1972	71.5	7.0	28.2	106.7	205.5	23.2	16.6	11.0	256.3	363.0	1,213.9
1973	78.2	7.7	29.6	115.4	222.1	28.1	17.7	11.7	279.6	395.1	1,253.1
1974	83.2	8.8	32.0	124.0	247.4	32.4	21.0	12.2	313.0	437.0	1,293.6
1975	92.0	11.1	35.3	138.4	284.7	37.3	24.0	15.0	361.0	499.4	1,369.6
1976	104.8	10.5	40.8	156.1	309.7	30.7	28.3	16.4	385.1	541.3	1,388.0
TO 1976[e]	26.2	2.6	10.2	39.0	77.4	7.7	7.1	4.1	96.3	135.3	347.0
1977	118.9	12.6	55.6	187.0	321.2	39.1	32.7	21.9	414.8	601.8	1,483.1
1978	134.5	16.5	57.9	208.8	374.9	40.1	34.7	22.4	472.1	680.9	1,582.5
1979	156.3	21.1	64.6	242.1	413.5	46.7	37.1	27.2	524.5	766.6	1,663.0
1980	162.8	27.5	71.6	261.9	456.4	55.9	48.4	30.5	591.3	853.1	1,709.7
1981	174.3	33.3	83.0	290.6	501.2	59.1	53.5	38.2	652.1	942.7	1,728.2
1982	199.2	36.2	107.6	343.0	545.2	62.5	61.3	45.5	714.6	1,057.6	1,790.3
1983	204.9	38.9	95.2	339.0	576.5	65.4	66.7	49.1	757.7	1,096.7	1,702.5
1984	210.5	38.5	103.2	352.3	621.8	66.3	71.0	54.4	813.5	1,165.7	1,748.6
1985	221.0	35.9	112.4	369.4	678.3	70.5	79.1	61.5	889.3	1,258.7	1,786.7
1986	222.7	35.8	140.6	399.1	741.7	69.4	85.1	70.2	966.5	1,365.6	1,829.5
1987	230.8	36.8	148.1	415.7	778.8	75.4	93.8	85.1	1,033.1	1,448.8	1,831.7
1988	247.8	42.2	153.5	443.5	823.4	84.8	99.1	91.1	1,098.3	1,541.8	1,874.8
1989	261.0	48.9	169.7	479.6	894.4	92.4	111.3	102.1	1,200.2	1,679.8	1,932.7
1990	272.8	54.1	188.6	515.5	950.1	102.4	126.6	112.4	1,291.5	1,807.0	1,985.2
1991	290.8	57.8	199.4	548.0	985.9	113.6	134.0	114.8	1,348.4	1,896.3	1,984.5
1992	316.6	60.7	221.3	598.7	981.5	116.1	143.4	121.0	1,362.1	1,960.7	1,996.7
1993	331.0	68.6	249.0	648.5	985.4	110.0	146.1	134.8	1,376.3	2,024.8	2,024.8
1994	353.2	79.8	270.0	703.0	1,010.9	116.7	152.9	148.2	1,428.7	2,131.7	2,073.6
1995	356.5	83.8	285.8	726.1	1,048.9	114.2	155.3	148.4	1,466.8	2,192.9	2,060.6
1996	344.1	83.1	288.3	715.6	1,049.5	120.5	162.5	164.2	1,496.8	2,212.4	2,022.3
1997	339.6	88.4	290.9	718.9	1,081.7	127.4	177.7	168.5	1,555.3	2,274.2	2,017.2
Annual growth rates							(percentages)				
1972-1997	6.4	10.7	9.8	7.9	6.9	7.1	10.0	11.5	7.5	7.6	2.1
1990-1997	3.2	7.3	6.4	4.9	1.9	3.2	5.0	5.9	2.7	3.3	0.3

SOURCE: Alston, et. al.

NOTE: Includes all 50 SAESs, forestry schools, 1890/Tuskegee institutions, veterinary schools, and other cooperating institutions.

[a] Includes formula funds, special grants, and competitive grants.

[b] Includes monies received from USDA grants, contracts, and cooperative agreements.

[c] Includes contracts and grants received from agencies such as the National Science Foundation, Energy Research and Devel. Administration, Department of Defense, National

[d] Institutes of Health, Public Health Service, National Aeronautics and Space Administration, and Tennessee Valley Authority.

[d] Includes funds received through industry grants and agreements.

[e] Includes appropriations for the period from July 1, 1976, to September 30, 1976, the so-called transition quarter (TQ) whereby the federal government moved from a fiscal year ending 30 to one ending September 30.

[f] Deflated wi.. .. revised and updated version of the U.S. agricultural R&D deflator fro.. .. ardey, Craig, and Hallaway (1989).

Table 6 Summary of funds available for U.S. agricultural R&D

	1950 - 1959	1960 - 1969	1970 - 1979	1980 - 1989	1996	1997	(1950 - 1997)
Funds available		(millions U.S. dollars per year)					(percentages)
SAES research	89.55	200.18	483.68	1,212.89	1,766.07	2,234.55	8.06
USDA research	46.08	109.32	258.58	500.37	614.08	653.68	6.78
Total public research	135.63	309.50	742.26	1,713.25	2,380.15	2,888.23	7.70
Total private research	na	300.30	746.70	2,0053.40	3,012.00	3,416.00[b]	9.17[c]
Extension	99.62	186.70	415.33	955.88	1,264.05	1429.15[d]	6.98[e]
Funds available		(millions 1993 U.S. dollars per year)					
SAES research	679.19	983.21	1,331.92	1,752.52	1,940.22	1,982.00	2.71
USDA research	347.75	539.23	711.77	732.69	674.63	579.80	1.49
Total public research	1,026.95	1,522.44	2,043.68	2,485.20	2,614.85	2,561.80	2.37
Total private research	na	1,472.77	2,044.86	2,964.94	3,309.01	3,478.71[b]	3.25[c]
Extension	760.93	924.47	1,168.21	1,390.08	1,388.69	1,390.2[d]	1.55[e]
Funding ratios							
SAES research/total public research	0.66	0.65	0.65	0.70	0.74	0.77	0.34
SAES research/USDA research	1.97	1.83	1.89	2.40	2.88	3.42	1.20
Public research/Private research	na	1.04	1.01	0.84	0.79	0.76[b]	(-.98)[c]
Total public research/Extension	1.34	1.64	1.83	1.79	1.88	1.92[d]	1.06[e]

Source:Alston, et. al.
[a]Deflated with a revised and updated version of the U.S. agricultural R&D deflator from Pardey, Craig, and Hallaway (1989).
[b]1992 figure.
[c]Growth rate for 1960-1992 period.
[d]1994 figure.
[f]Growth rate for 1950-1994 period.

Table 7 R&D expenditures by commodity, U.S. Department of Agriculture (USDA) and state agricultural experiment stations (SAESs)

	USDA			SAESs		
	1970	1980	1993	1970	1980	1993
	(percentages)					
Crops	35.3	30.9	36	37.6	35.3	31.8
Corn	1.7	2.3	3.9	3.3	2.9	2.8
Rice	0.5	0.4	0.6	0.4	0.5	0.8
Wheat	2.3	2.1	3	2.5	2	2.2
Soybeans	1	2.6	3.1	2	3.2	2.4
Fruit	5.5	4.5	5.5	7.4	6.1	4.9
Vegetables[a]	4.1	3.5	4.7	6.4	6.5	6.5
Cotton[b]	8	4.7	4.5	2.7	1.8	1.3
Tobacco	2.6	0.9	0.7	1.3	0.8	0.7
Range, pasture, and forage	3.7	4.7	4.6	4.5	4.9	3.6
Other	6	5.3	5.3	7.1	6.5	6.5
Livestock	19.4	16.4	15.4	26.3	24.8	23.3
Poultry	3.3	2.2	2.7	5.2	3.7	3.1
Beef cattle	5.3	5.4	4.3	7.6	8.7	6.8
Dairy cattle	5.1	3.5	3.3	6.9	6	5.2
Swine	2.5	2.8	3	3.1	3.4	3.1
Sheep and wool	2.1	1.5	1.2	1.9	1.4	1.5
Other	1	1	1	1.5	1.6	3.5
Natural and recreational resources	13.3	12.1	13	8.5	8.8	9.1
Trees, forest, and forest products	17.3	16.9	15.9	4.6	6.4	6.9
Fish and game	0.7	1.6	2.3	2.3	2.9	4.4
Human resources, organizations, and institutes	6.3	7.5	9.5	5.1	5.6	5.6
Other	7.7	14.5	7.9	15.5	16.1	18.8
Total	*100*	*100*	*100*	*100*	*100*	*100*

SOURCE: Alston, et. al.
[a]Includes potatoes.
[b]Includes cottonseed.

Table 8. Public-sector animal research relative to commodity value in 1970, 1984, and 1996.

Commodity	SY	Research Expenditure ('000$)	Production (million $)	Research Intensity[a]	Research Expenditures (million 1993$)[b]
1970					
Layers	122.1	6,719	2,034	0.33	24,964
Broilers	132.2	7,287	1,496	0.49	27,075
Turkeys	39.3	2,583	485	0.53	9,597
All Poultry	403.7	22,577	4,192	0.54	83,885
Beef	510.9	33,840	13,730	0.25	125,733
Dairy	515.8	31,345	6,512	0.48	116,462
Swine	197.8	14,593	4,444	0.33	54,220
Sheep & Wool	163.5	9,963	386	2.58	37,018
Total[c]	2,032.6	126,931	29,528	0.43	471,612
1984					
Layers	61.8	10,677	3,608	0.30	16,016
Broilers	85.1	13,707	5,520	0.25	20,561
Turkeys	46.5	8,566	1,581	0.54	12,849
All Poultry	336.9	56,789	11,145	0.51	85,184
'f	614.1	129,822	29,484	0.44	194,73
Dairy	461.5	92,974	18,244	0.51	139,461
Swine	286.1	64,069	9,509	0.91	96,104
Sheep & Wool	127.0	23,805	464	5.13	35,707
Total[c]	2,310.9	453,281	70,774	0.64	679,921
1996					
Layers	40.1	12,989	4,139	0.31	11,872
Broilers	95.4	29,988	12,347	0.24	27,409
Turkeys	42.5	12,991	2,841	0.46	11,874
All Poultry	306.1	91,915	19,947	0.46	84,010
Beef	467.7	178,383	33,846	0.53	163,042
Dairy	381.8	143,802	20,888	0.69	131,435
Swine	269.9	98,850	10,930	0.90	90,349
Sheep & wool	121.7	42,634	608	7.01	38,967
Total[c]	2,108.0	720,919	89,359	0.81	658,920

SY = scientist-years.
Production = a three-year moving average of annual cash sales.

search Intensity = $ of research ÷ $ of production x 100%.
eflated with a revised and updated version of the U.S. agricultural R&D deflator from Pardey, Craig and Hallaway (1989).
[c]Columns will not add to totals because some commodity categories are not mutually exclusive and some minor commodities are not listed separately. Also, some animals research cannot be allocated to individual commodities.

Sources: Fuglie, et. al.

Table 9. Public-sector animal research by sources of funds

Commodity		('000 of 1996 dollars) Federal	State	Non-gov	(%) Federal	State	Non-gov
Layer	1970	23,027	10,322	2,931	52.8%	36.8%	10.4%
	1984	10,659	9,166	2,044	39.2%	49.7%	11.1%
	1996	7,749	5,734	1,502	44.3%	44.1%	11.6%
Broiler	1970	26,288	9,332	3,027	59.4%	30.7%	9.9%
	1984	13,829	11,062	2,213	43.9%	46.7%	9.3%
	1996	17,849	10,803	3,332	52.9%	36.0%	11.1%
All Poultry	1970	86,327	32,092	8,752	56.7%	34.0%	9.3%
	1984	58,524	44,120	9,159	45.7%	45.0%	9.3%
	1996	47,472	40,125	12,299	43.0%	43.7%	13.4%
Beef	1970	80,160	42,426	26,935	50.9%	30.0%	19.1%
	1984	102,960	83,128	41,587	44.4%	37.1%	18.5%
	1996	74,677	68,505	37,198	40.7%	38.4%	20.9%
Dairy	1970	80,147	41,820	17,140	55.0%	32.0%	13.1%
	1984	73,344	63,926	26,756	43.5%	39.8%	16.7%
	1996	55,642	57,048	33,108	37.3%	39.7%	23.0%
Swine	1970	42,844	17,461	8,848	56.8%	28.7%	14.5%
	1984	58,227	38,774	17,096	49.5%	35.0%	15.4%
	1996	45,895	38,532	16,418	44.4%	39.0%	16.6%
Sheep	1970	35,215	9,653	4,952	64.9%	23.2%	11.9%
	1984	25,234	15,519	3,790	53.0%	37.7%	9.2%
	1996	21,632	15,674	7,325	46.1%	36.7%	17.2%
Other	1970	51,817	27,461	6,409	44.5%	45.0%	10.5%
	1984	90,499	45,628	22,396	54.1%	30.8%	15.1%
	1996	77,687	56,151	37,485	43.4%	34.0%	22.7%
All livestock	1970	376,510	170,914	73,035	54.0%	32.2%	13.8%
	1984	408,788	291,099	120,784	47.4%	37.2%	15.4%
	1996	323,005	276,035	143,832	41.8%	38.3%	20.0%

Source: Fuglie et. al.

Table 10. Rate of return to animal research in the United States

Investigator	Year Published	Commodity	Period of Study	Annual Internal Rate of Return (%)
Peterson	1967	Poultry	1915-60	21
Bredahl & Peterson	1976	Poultry	1969	37
		Dairy	1969	43
		Beef, Swine & Sheep	1969	47
Norton	1981	Dairy	1974	33
		Beef, Swine & Sheep	1974	66
Smith, Norton, & Havlicek Jr.	1983	Poultry	1978	61
		Dairy	1978	25
		Beef, Swine & Sheep	1978	22
Norton & Ortiz	1991	Poultry	1950-82	46
		Beef, Swine & Sheep	1950-82	55
Huffman & Evenson	1989	Public livestock research (all)	1950-82	11
Huffman & Evenson	1993	Public livestock research (basic)	1950-82	83
		Private livestock research	1950-82	86

These studies used econometric models to relate investments in research to changes in animal productivity on farms. Studies using time series data evaluated changes in animal productivity over time. Studies using data from a single period compared investment in research to differences in animal productivity among states.

Source: Fuglie, et. al.

Question 4: What are the implications of regulating animal agriculture at the township, county, state and federal level?

The literature found in answer to the question of what are the implications of regulating animal agriculture at the township, county, state and federal level is sparse. A few studies by agricultural economists have approached the question on the periphery, but not directly. Other documents that were reviewed included opinion pieces on the effects of policies and the preferred manner for government to act. This section of the report first reports on documents that generally address the level of government at which the regulation of animal agriculture should occur. The report then specifically considers two reports on that address the question in Minnesota: two reports on county feedlot ordinances, and an analysis by the legislative auditor of Chapter 7020 regulations.

Innes (1999) conducted an informal review of policy efforts to regulate the environmental impacts of animal agriculture. In his conclusion, his own opinion, Innes suggests that taxing the external effect of animal agriculture so producers pay the environmental cost of their practices and, therefore, act efficiently to protect the environment is simply not feasible. He states that tracing the environmental cost of nutrient pollution to individual livestock facilities is extremely difficult and imprecise. Rather, Innes says, government should focus on the relationship between producer choices and environmental outcomes, and more importantly focus on the choices that can be observed by the government at a reasonable cost. Innes states that governments' role could be to reduce the incentives to apply manure excessively. He lists five policy options:

1. A chemical fertilizer tax to encourage the application of manure as a substitution;
2. Manure subsidies to encourage cost-effective off-farm marketing;
3. Regulating irrigation to promote the use of irrigation systems that reduce the cost of spreading manure at more distant locations, hence spreading manure over more land;
4. Crop selection mandates to grow crops that have high nutrient uptakes; and
5. Regulating waste treatment to reduce the environmental damage from a livestock operation.

Innes suggests that these reductions may reduce nutrient pollution but rarely will it tax producers for the harm that they cause. Additional spatial restrictions or incentives are needed to elicit both efficient levels of production and an efficient spatial arrangement – producing a given level of output with facilities that are of efficient size and number and location. Spatial regulations along with observable choices that affect environmental outcomes (the five policy options above), have more potential to reduce animal agriculture's impact on the environment than present policies. Present policies, Innes states, are short on scale regulation, producer liability, flexible standards for prevention of spills from waste stores and measures that can provide firms with optimal incentives, rather than unenforceable directives, for environmentally friendly manure management.

The Center for the American Experiment created nineteen task forces to look at Minnesota State Government and to make recommendations to the Governor and State Legislature for the 1999 session and beyond. The task forces' made consensus recommendations based on the discussion

and work of the task force members. The task force which focused on agriculture made the recommendation to "consolidate all agriculture regulatory functions under the jurisdiction of the Department of Agriculture." The task force states that farmers achieving compliance with the state's environmental objectives should be made as easy as possible. Currently, agricultural regulatory functions are housed under a variety of agencies and boards, including not only the Department of Agriculture but also the Board of Water and Soil Resources, Department of Natural Resources, the Minnesota Pollution Control Agency and others. Housing regulatory authority in multiple agencies makes compliance requirements differ among agencies. Perarlstein and Meeks, (1999) in their report on the task forces, comment that one of the biggest complaints from farmers is that some agencies – most notably the MPCA – seem unable to explain exactly how to comply with regulations and rather simply say when farmers are in violation; this creates an unjustifiably adversarial atmosphere.

The question arises as to whether or not we can even measure the overall economic impact of policies on communities. Johnson and Scott (1999) describe a modeling tool which can be used to provide policy decision support for state and local government officials, including input-output modeling, cost-benefit analysis, and industrial targeting. In addition they describe a collaborative community policy analysis network that will eventually extend to selected rural comminutes in twenty-five states. The paper focuses on the specifications and development of the COMPAS econometric community models. The model could be utilized to study the impact local policy decisions on animal agricultural development.

In another study Sribastava and Batie (1999) looked at the Porter Hypothesis as a way of measuring the effect of public policy. The Porter Hypothesis relates the effects of environmental regulation on (a) technological innovation and (b) economic performance. Specifically, it asserts that innovation offsets can occur. These are a type of technological change that will "partially or more than fully offset the costs of complying with environmental regulation." The hypothesis is highly debated, in part because nomenclature has been careless. Also, the role of property rights in defining innovation offsets has been neglected. Recent changes in agro-environmental legislation provide an opportunity to more thoroughly investigate the hypothesis and its implications.

If the Porter Hypothesis has validity in agriculture, the policy implications are important. If agro-environmental regulations are designed as performance standards: they may be more cost-effective than other non-point pollution strategies, they may focus producer and contractor attention to search for innovation offsets, and they may induce innovation by redirecting research and development expenditures to cost minimizing pollution prevention technologies.

Local Feedlot Ordinances

See also the Land Use report for descriptions of the tools used by local governments in Minnesota to address the conflicts that arise with animal agriculture. The Land Use report also outlines the legal authority of the State of Minnesota and local governments to regulate animal agriculture through the use of land use tools.

Local governments in Minnesota have authority to enact zoning ordinances for regulation of animal feedlots. County and township interest in feedlot ordinances was stimulated at the beginning of this decade by the emergence of new facilities considered "large" by traditional standards. Fears of odors and to a lesser degree water quality risks, and concerns about ownership and community change caused the calls for controls. The researchers were unable to find academic literature discussing the implications of local government Informal, descriptive reports on efforts by two Minnesota counties were reviewed and are presented below.

In response to the changing feedlot industry in the early 1990's, Blue Earth County drafted a feedlot ordinance that requires all feedlots over 10 animal units to obtain a three-year county permit. Land Use Permits must be obtained by existing and new feedlots and they must be renewed after a site visit every three years. The County also has a delegation agreement with the MPCA to act for the state in issuing certificates of compliance for feedlots with up to 1000 animal units. The County has blended traditional county and state activities in their program. According to Charles Peterson, Blue Earth County Feedlot Officer, in an unpublished paper (Peterson 1998), the ordinance and permitting program have been successful. All existing and new feedlots in Blue Earth County have received site visits and inspections. Peterson observes that people's fears that the "tough" regulations would destroy the well-established feedlot industry in the County and would send producers to neighboring counties with "looser" regulations have not come true.

Another example of local government response to animal feedlots is the work of the Lyon County Township Association. The report from their work describes the issues of importance and their perspective on local and state level controls. Seventy-two representatives of the Lyon County, Minnesota Township Association met in April1998 and prioritized the topics they felt to be of greatest concern as the county developed a feedlot ordinance. The highest priority items selected (and listed in order) were:

1. Economic viability of livestock producers and general business and grain producers,
2. Groundwater pollution,
3. Absentee ownership,
4. Scientific based regulations,
5. Setbacks/health impact,
6. Air quality,
7. Impact on property values,
8. Agricultural preservation,
9. Appropriateness of township regulation,
10. Groundwater usage and 10 tie) Individual and corporation.

Originally many felt that county authority to enact zoning ordinances applied only to land use provisions (such as setbacks/separation distances) and did not include environmental regulations (such as nutrient applications rates) which are addressed by the MPCA in its feedlot permitting process under Minnesota Rules, Chapter 7020. This view was based on the concept of preemption by the state of some local authority over animal agriculture because of the extensive state regulation of these facilities. However, ordinances almost immediately began addressing a variety of feedlot issues including land use, water quality, and much less commonly, air quality.

Due to MPCA's role in regulating the environmental impacts of feedlots, the question of whether local governments can address environmental issues with their land use regulations, however, is open to significant question (the issue of *preemption*). In the *Crooks Township, Renville County v. ValAdCo.,* 504 N.W.2d267 (Minn.Ct.App 1993) case, the Minnesota Court of Appeals struck down a township's attempt to regulate the establishment of a feedlot because regulation involved a permitting system, applicable only to feedlots, that was very similar to the state's environmental review permitting requirements. It is important to note that this decision came from the Minnesota Court of appeals, not the Supreme Court., and that it involved a Township, not a County.

The inclusion of environmental regulations in county feedlot zoning ordinances was challenged in the courts in the 1995 District Court case of *Blue Earth County Pork Producers, Inc v. Blue Earth County.* The District Court judge ruled that the county could include manure management regulations in their feedlot ordinance. The fact that it involved a county rather than a township may or may not explain why the district court reached a conclusion that on its face appears inconsistent with the holding of the Minnesota Court of appeals in the Crooks Township case.

The Minnesota Supreme Court has not addressed these issues.

Chapter 7020 Regulations

The major state program regulating feedlots is authorized by Minnesota Rules, Chapter 7020 and conducted by the Minnesota Pollution control Agency. A major review of that program was made by the Legislative Auditor and reported in January 1999. (Noble 1999)

In recent years, Minnesota has experienced a significant growth in the number of large animal feedlots, particularly swine facilities. Citizens have raised concerns about the impacts of feedlots on both water and air quality. In April, 1998, the Legislative Audit Commission directed the Office of the Legislative Auditor to evaluate the environmental regulation of feedlots by the Minnesota Pollution Control Agency (MPCA) and the counties participating in the MPCA feedlot program. The study included interviews with MPCA management staff, county regulatory staff, other state and local agency staff, livestock producers, environmental groups, concerned citizens, and other state and national experts. MPCA permit, enforcement, and environmental review files were also analyzed. County regulatory officials were surveyed and some were personally visited by the staff completing the study. Existing reports and

literature was reviewed on feedlot pollution and regulation, including regulatory activities in other states, were reviewed. The Legislative Auditor's study also included on-site visits to several feedlots in Minnesota to see firsthand the steps being taken to address water and air pollution concerns.

The study found that the MPCA feedlot program had several strengths, including the design standards applied to new or expanded feedlots, the monitoring of water quality at certain feedlots, and the relatively new monitoring of air quality. However the study also identified numerous weaknesses in the MPCA feedlot program. These weaknesses include a lack of timeliness in reviewing and approving permit applications, insufficient review of some permit applications, limited follow-up on expired interim permits, insufficient resources devoted to visiting sites prior to permit approval or during construction, insufficient oversight of feedlots once they are in operation except in response to complaints, poor tracking of staff responses to citizen complaints, a weak but improving enforcement program, little or no meaningful oversight of delegated county feedlot programs, and the failure to update rules since the late 1970's.

The study also indicated a wide variation in the quality and comprehensiveness of county feedlot programs. Some county programs are excellent, while others are inadequate. The study summarized that counties can be valuable partners for the MPCA feedlot program, but the agency needs to provide clear program expectations for counties and perform better oversight of county feedlot programs.

The study listed numerous specific observations and recommendations related to the MPCA feedlot program. These observations and recommendations have been divided into six categories. They are : permitting, environmental review, oversight, county feedlot programs, feedlot rules, and MPCA resources. Following is a summary of the observations and recommendations identified in the study in each of the six categories :

1. Permitting

Most of the permits that MPCA issues are either "interim permits" or "Certificates of Compliance". An interim permit is issued for new construction or for a feedlot that poses a potential pollution hazard to the environment. An interim permit expires after ten months and should be replaced with a certificate of compliance once construction is completed satisfactorily or corrective action has been taken to eliminate the pollution hazard. A certificate of compliance has no expiration date and indicates that a feedlot meets agency standards. MPCA also issues National Pollution Discharge Elimination System (NPDES) permits to certain large feedlots (over 1,000 animal units) that have the potential to discharge to waters of the state. About 16,000 feedlots in the state currently have state or county feedlot permits, and about 23 feedlots in Minnesota have a NPDES permit. Currently, MPCA charges a permit fee for NPDES permits, but not for other state feedlot permits. Before MPCA issues feedlot permits, the agency usually reviews plans and specifications for all proposed manure storage structures to ensure that structures are designed in a manner that will not degrade ground or surface water quality.

2. Environmental Review

Another function performed by MPCA and sometimes by counties is the environmental review of certain proposed feedlots. According to rules established by the Minnesota Environmental Quality Board (EQB) an environmental assessment worksheet (EAW) must be prepared for any proposed new or total confinement feedlot with a capacity of 2,000 or more animal units or an expansion of an existing total confinement feedlot resulting in an increase in capacity of 2,000 or more animal units. For partial confinement facilities an increase in capacity of 1,000 or more animal units requires an EAW. MPCA or a county may also require an EAW for a feedlot project of any size, based on the location, nature, or potential environmental effects of that operation. This EAW could be based on the knowledge of MPCA or county officials or upon evidence presented in a petition signed by at least 25 citizens. The number of EAW requests received by MPCA grew from an annual average of 10 requests from 1995 - 1997 to 22 requests in 1998. This has caused a considerable backlog for MPCA staff, since it typically takes four to nine months to complete a routine EAW.

3. Oversight

In addition to issuing feedlot permits, there is also a need for MPCA to provide ongoing oversight of permitted feedlots and scrutiny of unpermitted feedlots. A detailed feedlot inventory could help identify facilities needing a feedlot permit, as well as facilities that are a potential pollution hazard. In addition, a regulatory agency should periodically inspect all permitted feedlot facilities on an ongoing basis to ensure that facilities are being operated in accordance with permits and that pollution problems are not occurring. It is also important for MPCA and counties to ensure that appropriate steps are taken to protect the environment from water pollution when a feedlot closes and is no longer in operation.

4. County Feedlot Programs

MPCA's feedlot program depends on delegated counties to issue permits, oversee feedlot operations, and minimize environmental pollution from feedlots. Ideally, a good county feedlot program should have an inventory of feedlots in the county, know which feedlots pose environmental problems, and have a plan to address the pollution problems. County officials should also thoroughly review new and expanded feedlot permit applications and ensure that feedlots are constructed in accordance with MPCA rules and guidelines, local zoning ordinances, and sound engineering practices. County programs vary considerably in the degree to which they are funded and have the desired regulatory practices in place. Counties also vary in the type and extent of environmental risks that result from their geographical and geological features. Minnesota has feedlot programs in some counties that are less than adequate and programs in other counties that are exemplary and are more advanced than MPCA's regulatory efforts. There are 47 counties with designated county feedlot programs under the MPCA feedlot program.

5. Feedlot Rules

The study identified existing feedlot rules in Minnesota as one of the key reasons that there have been problems with animal feedlot regulation in the state.

6. MPCA Resources

The study identified fundamental resource problems that have adversely affected MPCA's performance in administering the state feedlot program..

GAPS IN THE LITERATURE AND RECOMMENDATIONS FOR ADDITIONAL RESEARCH

The social rates of return discussed in this paper are based on data for the entire country. An evaluation of the returns to animal research and extension investments in Minnesota would require a new study. Such a study would delineate the changes in output and input use over time for the major types of livestock and poultry produced in the state. Public research and extension investments in Minnesota over time would need to be documented. It would also be important to document public research investments in other states as well as private research investments to measure spill-over effects of these investments on the productivity of Minnesota's animal agriculture. The study would need to account for changes in quality of inputs and outputs over time. Efforts should also be made to account for environmental benefits/degradation of animal research and extension.

A study that deals with these issues would require two to three years to complete. However, it has the potential to produce estimates of the social rates of return to Minnesota's publicly funded investment in research and extension for each of the major types of livestock and poultry produced in the state.

Role of Government Research Needs Relating to Feedlot Regulation:

- Research that addresses the costs and effectiveness of various technologies would help policy makers and regulatory agencies enact requirements that realistically balance pollution control and economics:

- Costs and effectiveness of various technologies and approaches to reducing risk of odor, air pollutants, and nutrient runoff and leaching from livestock facilities, manure storage units, and land with manure applied. Priorities include models for odor plume dispersion based on various factors such as topography, weather, facility and manure storage technology and treatment methods, to help base siting decisions on more definable risks.

- Costs of implementing odor and nutrient loss technology and practices and their impact on production costs and industry location.

- Identification of the role of specie, operation size, technology, siting, etc. on potential air and water pollution. Results could help determine what sites to regulate.

- The logistics and economics of implementing regulatory programs to maximize impact and reduce cost:

- Study of the economics and efficacy of feedlot regulation. Most efficient and effective way(s) to deliver services and insure reasonable compliance. Variables such as level of government, staffing, pairing with incentive programs, etc. Also measure the effectiveness of incentives versus penalties.

- Consideration of how best to address the land use, environmental, and social/values aspects of feedlot regulation. Separately (different laws and agencies), or in combination?

- Identify the factors associated with differing levels of community conflict associated with feedlot siting and regulation.

- Identify how state, federal, and local tax laws and policies impact animal agriculture.

- Research on the effects of any of the laws and policies described in the report on individual livestock, poultry, and dairy producers, processors, marketers, or other industry interest groups. Research on the effect that any of these laws and policies have on the structure of the animal agriculture industry as a whole. Research on the laws that appear to have the most significant environmental, economic, social, and public health impacts on individual business entities, as well as, the structure of the animal agriculture industries to attempt to measure both the perceived and actual impacts would be beneficial.

- Research that attempts to identify the purposes of the various laws and policies, measures the extent to which these purposes have been met, and the obstacles that prevent better implementation of the purposes would also be beneficial.

- If in the GEIS process there are to be different alternative structures or scenarios compared, it may be useful to attempt to analyze how livestock, poultry and dairy producers would fair with existing laws under each of the scenarios. In addition, it would be useful to identify the types of government policies that would foster the different scenarios being compared.

- More research into the extent to which access to credit impacts various livestock, poultry and dairy producers based on size of operation, methods of production, and methods of marketing would be very useful.

LIST OF MAJOR ON-GOING WORK

The only on-going work on the Role of Government that was found during the literature review was the study by Mark Edelman of Iowa State University working with the National Task Force of Extension Specialists. The survey designed by the group to determine the impact of feedlot policies in each state is not yet complete. The survey results should be completed and published near the end of 1999. Preliminary results were discussed in the literature review.

SUMMARY OF COMMENTS ON DRAFT REPORT

The draft Role of Government report was commented on by CAC members and one outside reviewer. Other outside reviewers received the draft but were unable to respond due to vacation schedules. The general topic areas of the comments and the manner in which the comments were addressed in the final report are summarized below.

1. *What was the decision rule used to determine if materials were reviewed and included or excluded?* The decision rule was made much more explicit in the Critique of the Study Question section of the report. The Role of Government report uniquely considered legislation, law review articles, legislative history in addition to the academic literature relied on for other reports. In addition, since there was much concern expressed about the use of opinion pieces, we tried throughout the report to explicitly explain the nature of documents reviewed.

2. *Complete missing or incomplete answers to the scoping questions.* Answers to questions 1a. and 2a. were completed and the missing answer to question 3 was completed.

3. *Requests for more results to the questions of effectiveness/enforcement.* The research team conducted additional research on effectiveness but were only able to find one additional document on effectiveness of the Blue Earth County feedlot program. As stated, the question of effectiveness of policies would be served by additional research.

4. *Include a glossary of terms for the lay reader.* A short glossary is included at the beginning of the literature review.

5. *Clarifications and corrections on specific points.* To the extent possible, all clarification and correction comments were addressed in the final report.

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Industry Structure & Competitiveness Profitability and Economic Viability

D
E

Generic Environmental Impact Statement on Animal Agriculture:

A Summary of the Literature Related to Industry Structure and Competitiveness (D) And Profitability and Economic Viability (E)

Prepared for the Minnesota Environmental Quality Board

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Generic Environmental Impact Statement on Animal Agriculture

Economic Topic IID, Industry Structure and Competitiveness

and

Economic Topic IIE, Profitability and Economic Viability

Executive Summary

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Executive Summary

Business, production, processing, and distribution systems in the food chain are in a period of rapid change. These changes are in response to a host of dynamic economic and social forces such as global economic competitiveness, monetary policy, government regulations, consumer preferences, environmental stewardship, and food safety and new technologies, to the social and economic needs of farm families and rural communities. Business decisions on how to structure and operate the businesses to position themselves to survive and compete are increasingly influenced by external global forces. These decisions are typically subjective decisions based on specific situations and are continually being revised in response to a rapidly changing climate. Therefore, the nature of firms within the industry is a collage of various types of business organizations and the way they operate. There are no two firms alike in the way they operate.

Trends in the Minnesota and U.S. Livestock Industry

There may be valuable lessons that can be learned from the changes that the U.S. broiler, fed cattle, and processing vegetable sectors went through in the 1950s and 1960s. That transformation has been described as a four-step process: Forces outside farming trigger structural change, at first to exploit new conditions, and later to manage new risks. New technology, market conditions, and policies lead to 1) technological adaptation, 2) shift to new producing areas, 3) growth and development, and 4) adjustment to risk.

The livestock industry is composed of species subsectors that are very different from each other. They compete at the retail level. The poultry industry, broilers, turkeys, and eggs is quite integrated and concentrated. The beef cow calf industry is very dispersed, with many small producers on more marginal land, but beef feedlots that are more concentrated and integrated. The swine industry has been evolving in recent years toward greater concentration and integration. The dairy industry has been moving more slowly than swine in this direction. Because of these differences and differences in the input resources, readers are cautioned about making general conclusions that apply universally to a non-homogenous livestock industry.

The sectors that have shown growth since the early 1990s are hogs, layers, and turkeys. Turkey production has grown since the early 1993, but appears to have leveled off in the past year. The number of laying hens is also up by 1.3 million. Production contracting is the norm in the poultry industry, with 85 percent of broilers grown under contract in 1995.

Perhaps the big story is hogs -- there were 21 percent more hogs and pigs on Minnesota farms last December, compared to December 1992. The pig crop was also up 8 percent in 1998. The upward trend in hog numbers can be expected to level off and perhaps reverse itself as producers liquidate in response to the current disastrously low hog prices.

Consolidation of livestock production onto fewer farms is evident in Minnesota as it is nationally. The number of operations with hogs has declined almost 40 percent since 1993. Nationally, the changes are occurring primarily in the largest operations, which are gaining market share, and the smallest ones which are losing share.

According to a February 1999 national survey of nine the largest twelve pork packers, 64 percent of the slaughter hog purchases during January 1999 were priced under some contractual method other than the spot market. This was an increase from 57 percent in 1997. The latest figures on the level of production contracting in the swine industry are that 17 percent of 1997 slaughter hogs were farrowed under contract, and 30 percent were finished under contract. The largest year for producers signing production contracts was in 1997.

The swine industry has been undergoing rapid changes in recent years along the lines of the earlier sectors, that some authors have termed "industrialization." New technologies and management strategies that are thought to be playing a major role include improved feeding programs, health-enhancing technologies such as all in-all out rearing and early weaning, specialized breeding systems, more careful facility design and better information systems, and networked (cooperative) selling and/or buying among groups of producers, and information sharing among producers and between producers and processors. Some experts are concerned that the U.S. pork industry could lose market share to other major pork producing countries or regions. The Canadian prairie provinces, Argentina, and Brazil appear to be the major competitive threats.

Twenty Minnesota pork producers who were interviewed in late 1995 cited a number of specific reasons for joining swine production networks. Most of the producers were previously producing hogs in individually-owned farrow-to-finish operations. In general, they were all looking for a way to access the technology and systems they saw as necessary to achieve low cost production of the product quality and volume necessary to be competitive in the future. Within that general theme, some people emphasized product quality while others focused on volume or labor simplification. The types of arrangements ranged from small-scale, informal farmer-to-farmer formula pricing arrangements to large-scale, jointly owned sow units directed by hired management consultants.

Cattle and sheep numbers are down in Minnesota. Numbers of sheep and lambs are down by almost a third since 1993, although the inventory last January has started to rebound. Cattle on feed has also rebounded a bit this winter, which would be expected given the low feed prices. Beef cow numbers seem to be on a fairly steady downward slide. Not much change is evident in the number of cow-calf operations, while the number with cattle on feed is down eight percent. The information on the number of sheep operations is not out yet for this year, but was down substantially as of a year ago.

Dairy cow numbers slid by seven percent in 1997. They continued to decline in 1998 but the rate of decline was less. Minnesota dairy operations are also down, by 28 percent. Statistics show a wide diversity in the economic vitality of Minnesota dairy farms. Statistics show a wide diversity in the economic vitality of Minnesota dairy farms. Dairy farm management records suggest that many Midwest dairy businesses are highly profitable when compared to their competitors in the West, East, South, and elsewhere in the world. However, many others have the opportunity to be more competitive. Family economics and lifestyle needs and hopes are critical on-farm forces of change. Dairy profit margins have become slimmer while family living costs have risen. Opportunities for quality family time and for breaks in day-to-day routines to get away are growing more important to many families. No research-based studies were found on milk marketing contracts. The authors are aware of several incentives processors

are using to compete for producer milk such as quality premiums, discounts on hauling charges, management services, volume premiums, and various forms of formal milk contacts. The extent to which milk contracts are used is not available.

Impact of Government Policies on Profitability of Livestock Farms

We could find few published empirical analyses of the cost of livestock operations' compliance with environmental regulations, or studies that quantify how significant state-level corporate farming laws or environmental restrictions are in affecting locational shifts in livestock production.. One reason for the dearth of work on this area may be that the regulations are evolving so rapidly and vary so much across localities and farm types. One study (Mo-Abdalla) related several measures of environmental regulation to hog inventory shifts. They found that economic variables were more influential than regulatory differences. Whether or not a state had a corporate farming law did not seem important, but they did not consider specific provisions of the laws.

Another study of dairy farms' cost of compliance with certain EPA regulations found that moderate size dairies would be affected more adversely than large size dairies. Dairies that were already in financial trouble could be put out of business. Many of these dairies, however, could go out of business regardless of the EPA requirements, albeit at a later date. Large scale dairies that were not already in financial trouble appeared to be able to amortize the extra capital investment costs. This suggests that moderate size dairies faced with needing to make investments to meet the EPA standards may choose to expand the scope of their operations, if financially able. While such expansion would require an even larger investment, it also would hold the potential for making the dairy more efficient and competitive.

The EPA has announced that it wants final action on national guidelines by December 2001. One analyst argues that standardized national standards would tend to push location decisions to the local level, where some communities are eager to embrace the industry while many others are not. He also argues that standardized national environmental regulations would highlight the role of corporate farming laws.

Does agriculture receive special treatment in terms of public policy and public sentiment, and should it receive such special treatment?

There are several rationales for the perception that agriculture is viewed more favorably by the public than are other industries, and that it deserves special treatment. Three rationales are: 1) a moral or Jeffersonian argument that farmers are more deserving than other people just because they work the land and produce a product, food, which is more essential than many other products; 2) a regional economics-based argument that at least some rural communities have few other industries to depend on for tax revenues and trade; and 3) a social argument that owner-operators are more likely to be stable and involved in the local community than are people who work for others, and that owner-operators make up a larger share of the agriculturally-based population than for other industries. Several studies are cited that attempted to assess public perceptions of agriculture and farm problems.

Concentration of Buyers of Farm Products

Several previous literature reviews on the meatpacking industry, along with sources on dairy marketing and food marketing institutions, address this issue. There are different perspectives on the tradeoffs implicit in the industry concentration issue. Some authors have focused on the concern that a handful of firms seem to be positioned to at least potentially control the food system and capture higher-than-competitive profits at the expense of independent producers and rural communities, suggesting the need for government intervention.

Statistical studies of meatpacking industry performance seem to indicate a (statistically) significant but small departure from competitive conduct. The implication is that both consumer and producer welfare could be increased by steering packer behavior toward closer conformity with the perfectly competitive benchmark. The question is whether one should target the structure or conduct of the industry.

The question of whether the negative effects of greater market power from industry consolidation outweigh the positive efficiency gains remains an issue. One computer simulation study of the beefpacking industry found that the anticompetitive effects of a 50 percent increase in concentration were, at most, on the order of 2.4 percent. As a measure of efficiency gains, they estimated that a 50 percent increase in the size of a representative plant in the industry is likely to be generate savings of 4 percent. They concluded that the structural changes in beef packing in recent years have been welfare enhancing on balance. A later econometric study also found that the positive cost-efficiency effect of beef industry consolidation outweighed the negative market-power effect. Azzam concludes from this that it might be preferable for policy to focus on industry conduct rather than structure. The aspect of conduct that policy should focus on is the degree to which competing firms may be able to coordinate their pricing without conspiring in the usual sense of the term - that is, without any overt or detectable acts of communication. The challenge is to develop creative measures, in the form of marketing institutions, to dissipate the rents from implicit collusion. Where acts of communication are overt and detectable, as was the case in the beef cartel at the close of the last century, antitrust remedies come into play.

A previous literature review of the relationship between food retailing concentration and consumer prices, power and profits yielded mixed results, especially with regard to price. They noted that U.S. food expenditures are falling relative to household income, which calls into question the importance of concentration as a societal concern. One cited study found that greater concentration at the wholesale level was associated with lower retail food prices, probably due to economies of scale being passed on to consumers. Overall conclusions were that increased retail level concentration has been associated with both increases in prices in some food categories and decreases in others. Profits uniformly increased with concentration, but the reason was unclear. Part of the increase was attributed to lowering costs through the use of information technology and vertical coordination.

There seems to be greater concern that wholesale meat market concentration exercise of market power by packers' and retailers may be detrimental to producers. An analysis of randomly selected meat market reports questioned whether wholesale price reports may be biased downward because lower quality carcasses and cheaper cuts are sold through channels that are

reported while higher quality ones fabricated for their own retail customers or into specialty cuts that do not fit into reported standard commodity categories. On the legal front, the 1977 Illinois Brick Co. ruling by the U.S. Supreme Court held that only direct purchasers or sellers may sue a firm for damages due to the use of market power. This ruling presents an obstacle to farmers who might be in the position of being damaged by depressed wholesale prices that are passed on by packers or other intermediaries.

Marketing Contracts, Price Discovery and Market Fairness

The increased use of production and marketing contracts in the swine industry is well documented. Several studies have found that captive cattle supplies had a relatively weak negative impact on prices. Two more recent studies found that pork producers selling smaller lots of hogs received lower prices than those with larger lots, although differences in procurement methods and quality characteristics make the results somewhat difficult to interpret.

Ownership and Control of Livestock and Livestock Facilities

The USDA tracks foreign ownership of farmland in the U.S., which stands at slightly more than one percent. We suspect, however, that classifying owners by local community or state of residence, and/or by principal occupation, might be what is really of interest. Corporations make up a much smaller share of farm businesses than is the case in the rest of the economy.

Broadening the Control Question

It might be useful to broaden the discussion of control from control of livestock in Minnesota to control of the food system generally. Boehlje and Schrader argue that a fundamental issue in any negotiation-based coordinated system is the point (or points) and source of power or control. Who dictates, or has the most control, over the performance of the system, of the sharing or risk and rewards? And what is the source of that power or control? They argue that there are two fundamental points of control and one fundamental source of power in a negotiation-based coordinated food production and distribution system. The first point of control is the end user or consumer and those firms that have intimate contact with the consumer. The second point of power is the raw material suppliers, especially suppliers of inputs with the fewest substitutes - the genetic material in plant and animal production, the seed and breeding stock. In both cases, the source of this power is knowledge.

What motivates livestock producers and processors to start, continue, expand, and quit business? What are the characteristics of those starting, continuing, expanding, and quitting?

We found a study that documented the characteristics of dairy farms that expanded and reasons they did so. Another study described Iowa pork producers who quit. It has been argued that federal commodity programs prior to 1996, by stabilizing crop prices, may have minimized a source of risk inherent in specialized broiler operations and beef feedlots, thus contributing to the shift away from diversified crop-livestock farms. There is limited documentation to the effect that low grain prices in the 1990s have induced formerly specialized Minnesota grain producers to invest in swine finishing enterprises. At more of an aggregate level are several discussions of the motivations for the development of integrated food supply chains.

Economies of Size

A traditional way of analyzing economies of scale (or size) in agriculture has been to compare average production costs per unit for different sized operations, based on university-sponsored farm business summary programs or surveys. Much of the growth in the pork and dairy industries today is coming in "mega" operations which are less willing to share data and, in any case, are often backward or forward integrated in ways which make costs difficult to sort out. It is becoming more difficult to analyze costs by size of operation. Some economists argue that looking at where facility investments are occurring may actually provide a better indication of how production will occur in the future than cost comparisons provide.

Impact of Various Production and Marketing Arrangements and Livestock Production Systems

There are many different production and marketing arrangements in use in livestock production, such as futures and options trading through the established futures markets, and marketing contracts with processors that may extend for periods of a few months up to five years or more. Analyzing them involves issues such as how broad the adoption is and where the industry is in its price-production cycle. Producers may have multiple goals such as enhancing price versus reducing risk. Marketing contracts may affect processing costs, which may by passed back to producers as enhanced prices and margins in the short run. In the longer run, the cost savings are expected to be reflected in increased production while margins return to normal levels. Dairy producers have had less choice in production and marketing arrangements. A wide variety of production management practices have been shown to affect dairy farm profitability.

Changes in hog procurement practices are causing a number of problems for farmers who continue to rely on the spot market, including delays of several days until packers can accept delivery of animals, rather than the previous situation where farmers could call and deliver their hogs the same day, closing of local buying stations, requiring greater travel distances, perceived price reductions relative to what large producers were receiving (it is not clear what information about large producers' prices they were using to make this comparison, or how accurate their information was), and missing out on quantity premiums or other "special deals" that large producers were receiving.

Much of the debate about the fairness of long-term hog marketing contracts revolves around whether quantity premiums paid to producers under long-term marketing contracts or for larger spot market lot sizes are unreasonable compared to what is paid for smaller spot sales. "Reasonableness" relates to how such premiums compare to differences in packers' procurement and operating costs. Two relationships that have not been quantified very well in past research include: 1) how packers' hog procurement costs vary with lot size (number of animals involved in the individual transaction), and 2) how much slaughter plant per unit operating cost increases when the plant is operated below or above optimum rates on any given day. The increased use of contracts together with more concentrated ownership of germplasm has raised concerns of a possible shift in bargaining power away from producers and their receiving a smaller share of revenue from production.

The annual reports of the Minnesota State College University (MnSCU) Farm Business Management Program and the Southwestern Minnesota farm Business Management Association

do provide some evidence of how returns from contract production of hogs compare with non-contract hog finishing. The 1994 through 1997 years were profitable ones for independent hog finishing operations, but they lost money in 1998. The contractee producers earned less than the independents earned on average, but the contractees only experienced a slight decline in hourly earnings in 1998 compared to the large losses that the independents experienced.

Livestock has always been produced under a variety of production systems. Systems may be becoming more standardized, but producer interest in alternative systems remains high. For swine, three systems that are widely discussed are hoop barns, pasture farrowing, and the Swedish deep-bedded system. For dairy, intensive rotational grazing is widely discussed. Research is underway at the University of Minnesota to collect financial performance data from Minnesota farms using these alternative systems, but it will probably take several years before definitive results are available.

Generic Environmental Impact Statement on Animal Agriculture

Economic Topics IID, Industry Structure and Competitiveness and Economic Topic IIE, Profitability and Economic Viability

Topic Leader: William F. Lazarus

INTRODUCTION

This literature review is organized in the same manner as the study questions laid out in the GEIS scoping document. Some of the study questions under topic E are closely related to questions under topic D, such as E3 on effects of government policies and D1 on choices of business organization. Several questions within each topic are also closely related. After conferring with Environmental Quality Board staff, we have rearranged the order of such questions in order to improve the flow of the presentation.

It was suggested in our instructions that the report be organized with separate sections for 1) a critique of the study questions regarding their researchability, and 2) a critical review of the information sources themselves. We found that the readability of the report was improved by combining our comments on each question together with our review of information sources for the same question, so we do not have those two overall sections broken out in this draft.

We would like to call attention to a brief discussion of the scientific method included in (Morse and Guess-Murphy 1999):

> "... Policy decisions require a combination of facts and values. While the scientific method can provide solid information on the facts, it can say nothing about what values people should use to make the final policy decisions (Barrows, 1993). For example, while science can report on the economic benefits and environmental costs of a new livestock operation, the ultimate policy choice about zoning issues depends on how much local people value the economic benefits vs. environmental quality. Research on external benefits and costs, once satisfactorily completed, can tell us what the trade-offs are between different types of impacts. This research can not tell us how much we will give up one to get the other. Benefit/cost analysis, which attempts to provide monetary values for both benefits and costs, is not covered in this portion of the report.
>
> Good research depends upon using the scientific method. The scientific method includes two major features: 1) refutable hypotheses and 2) replicable research methods. First, consider refutable hypotheses. Popper argues that "science produces and tests refutable hypotheses and non-science does not. Scientific knowledge consists of the set of refutable hypotheses which have not yet been falsified" (Fox, 1997, p. 52). A hypothesis is a tentative explanation of facts or the connections between two variables. A refutable hypothesis can be tested against data and shown to be false. If it is not refuted when the data is applied, then it is accepted as probably true. Second, consider replicable research methods. Researchers are trained to be highly skeptical of research done by their

> peers. For a scientific test to be credible the scientist must report his research methods in so much detail that another scientist could replicate the research. Naturally, if the first scientist has honestly reported his results, then the second scientist replicating the test with the same data and the same research methods should get the same results. Without a detailed description of the methods in any research report it is difficult to evaluate the quality of the research.
>
> A second type of research involves estimation procedures using the best available knowledge together with explicit assumptions. These operation research models are not trying to discover new facts but are merely using existing knowledge in models where there are complex relationships between variables. While operations research models do not have refutable hypotheses, they share the need for clearly articulated research methods. The assumptions, the data, and the computational methods need to be clearly specified to allow an evaluation of the validity of the research. This quality of being clearly specified is often called 'transparency.'"

As with all of the authors of the GEIS literature review, we faced a decision as to what constitutes "literature" that should be included in the review. Our study questions seemed to be calling for a great deal of basic descriptive information on the current situation. Some of the publications we were able to locate provide a lot of background on methods, so that it is clear how the research could be replicated if desired. In many other publications, less is said about methods. In some cases, we cite publications because they contain factual data that can be verified, but the same publications may also include statements which are not verifiable and which some of our readers may disagree with. They may contain value judgments, which we do not wish to take a stand on. When we cite such publications, we will attempt to direct attention to the factual information that we consider relevant to the GEIS.

Business, production, processing, and distribution systems in the food chain are in a period of rapid change. These changes are in response to a host of dynamic economic and social forces such as global economic competitiveness, monetary policy, government regulations, consumer preferences, environmental stewardship, and food safety and new technologies, to the social and economic needs of farm families and rural communities. Business decisions on how to structure and operate the businesses to position themselves to survive and compete are increasingly influenced by external global forces. These decisions are typically subjective decisions based on specific situations and are continually being revised in response to a rapidly changing climate. Therefore, the nature of firms within the industry is a collage of various types of business organizations and the way they operate. There are no two firms alike in the way they operate. Availability of research based information as described by Morse to address several of the questions on business structure and competitiveness is limited due to the dynamics of the industry and the historic nature of research based information. Therefore these authors have supplemented verifiable research based information available with industry facts, statistics, and knowledgeable experts interpretations of the assessments to more fully answer the questions posed with current thinking and ideas. The authors used care to be objective in selecting these references for which there appears to be general agreement.

Readers must also be aware that the livestock industry is composed of species subsectors that are very different from each other. They compete at the retail level. The poultry industry, broilers, turkeys, and eggs is quite integrated and concentrated. The beef cow calf industry is very dispersed, with many small producers on more marginal land, but beef feedlots that are more concentrated and integrated. The swine industry has been evolving in recent years toward greater concentration and integration. The dairy industry has been moving more slowly than swine in this direction. Because of these differences and differences in the input resources, readers are cautioned about making general conclusions that apply universally to a non-homogenous livestock industry.

Changing linkages between producers and those firms that provide inputs to producers and buy their products, are key elements of the structural change occurring in food distribution and distribution. The NE-165 Regional Research Project, "Private Strategies, Public Policies, and Food System Performance," includes researchers from U.S. land grant universities and government agencies. This group held a conference in 1995 on "Vertical Coordination in the Food System." Updated versions of the conference papers were recently published in a book which focuses on the changing nature of linkages in the food chain (Royer and Rogers 1998). The book covers a wide range of topics including: how to measure the degree of vertical coordination among industry segments involved in manufacture of a particular product (e.g. ice cream or animal feeds); effect of ownership on contract structure in the beet sugar industry; and alternative models for the future of pork production.

There is one publication that deserves special mention as a source of data: (Anonymous 1997a). We recognize that it contains expert opinion-based predictions about the future of the food system. These predictions are believed to be reliable, but they are also by nature unverifiable. The report also contains occasional statements that some readers may view as value judgments. The primary objective of the book is to present a fifty-member Purdue University faculty task force's best sense of what the food and agricultural system will look like in the first part of the 21st century. They expect that the analysis will be useful for at least three different levels of decision making:

1) specific sectors such as particular types of livestock operations,
2) linkages and interdependencies between and among the various stages of the food system, and
3) implications for input supply firms.

They focus on four categories of drivers of change:

(a) demand/consumption/demographics, such as changing export markets, international competition and actions of competitors, changing age and work habits of U.S. families and consumers, and changing attitudes about food safety and quality,
(b) productivity and technology, such as the status of intellectual property rights,
(c) government regulation and policy, such as antitrust and international trade policy, and
(d) resources such as capital, human resources, and information and industry infrastructure as well as the environment.

Two USDA reports provide overviews of vertical coordination in the pork and broiler industries. The first reviews the trend data on pork packer coordinating arrangements and describes a procedure they used to estimate the impact of improved quality and lower acquisition costs on retail prices and consumer welfare (Martinez 1997). The second finds that recent changes in the

structure of the U.S. pork industry reflect, in many ways, changes in the broiler industry (Martinez 1999). Vertical integration and production contracts in broiler production facilitated rapid adoption of new technology, improved quality control, assured market outlets for broilers, and provided a steady flow of broilers for processing. Incentives for contracting and vertical integration in the pork industry may yield comparable results. If so, these arrangements might lead to larger supplies of higher quality pork products at economical prices. The report provides historical background on vertical integration in the broiler and pork industries; explores the motives for vertical integration and contracting; examines the relationship between vertical integration and the price and quality of pork and chicken products; and explores the public policy implications of vertical integration in the pork industry. Increased contracting, integration and consolidation also result in concerns about market power and barriers to entry. Independent producers' production and marketing decisions may be distorted due to reductions in the amount and accuracy of publicly available market information.

Critique of Study Questions in GEIS Scoping Document

Most of the questions seemed fairly straightforward, and we don't have a lot to say about them. Some of the study questions under topic E are closely related to questions under topic D, such as E3 on effects of government policies and D1 on choices of business organization. Several questions within each topic are also closely related. After conferring with Environmental Quality Board staff, we have rearranged the order of such questions in order to improve the flow of the presentation.

As with all of the authors of the GEIS literature review, we faced a decision as to what constitutes "literature" that should be included in the review. Our study questions seemed to be calling for a great deal of basic descriptive information on the current situation. Some of the publications we were able to locate provide a lot of background on methods, so that it is clear how the research could be replicated if desired. In many other publications, less is said about methods. In some cases, we cite publications because they contain factual data that can be verified, but the same publications may also include statements that are not verifiable and that some of our readers may disagree with. They may contain value judgments that we do not wish to take a stand on. When we cite such publications, we will attempt to direct attention to the factual information that we consider relevant to the GEIS.

Critique of specific questions:

Question D1. What choices of business organization are available to livestock producers in Minnesota and in other states? To what degree are livestock producers allowed to operate agricultural systems interdependently as opposed to independently in Minnesota and in other states and what is the significance?

Federal and international agricultural policy is a very broad topic with a voluminous literature. The question was raised in a meeting of the GEIS Citizens' Advisory Committee as to the extent to which this response should address national-level policies in the U.S. and other countries, and how they might enter into the eventual GEIS policy recommendations. The sense of the group

seemed to be that the response should focus on describing recent national-level policy developments and economic trends which might most directly affect the outcomes of Minnesota's policy alternatives.

Question D3 - How are livestock businesses different from and similar to non-agricultural businesses with respect to the following factors, and what are the implications of these differences:

There are a tremendous number of ways in which livestock businesses and non-ag businesses are different and similar. This question as stated is much too broad to be researchable. Environmental Quality Board staff indicated that this question grew out of concerns such as: "Does agriculture receive special treatment in terms of public policy and public sentiment, and should it receive such special treatment?" and urged us to address the question from that perspective. From a practical standpoint, one way to narrow this question to a manageable scope would be to state a few specific policy issues that call for such a comparison. If that were done, we would be better able to start to focus on the similarities and differences that are most likely to be important to addressing those policy issues. For example, one policy issue might be: "Should the state give livestock facilities and other agricultural property preferential property tax rates compared to other businesses and residential property?"

Comments on the individual factors:

a. location

One approach to this would be to compare how dependent different county or metropolitan economies are on agriculture, versus other industries. A larger question might be how diversified county economies are, versus how dependent on any one industry, whether agriculture, mining, forestry, steel, or whatever. On the other hand, if the policy question of the moment is whether to enact some policy that affects the economic viability of agriculture, then knowing how dependent one's economy is on agriculture would help one predict the impact of the policy.

d. use of land as a resource

We have been able to locate few studies that directly compare use of land as a resource by livestock businesses and non-agricultural businesses. We have not delved very far into this topic due to uncertainty about what the real questions are and the criteria for comparison that are of interest. Further focusing of the question is needed to improve researchability. One possible way to narrow this question to a more manageable scope would be to consider only those aspects of land use that affect the amount of water pollution originating from land used by livestock businesses and other businesses.

g. public perceptions

We assume that the main desire here is to evaluate the often-heard perception that the public views agriculture more favorably than they do other industries and thus it deserves special treatment in government policies, but greater focusing of the question would be useful.

Question D5. What is the current situation and what are the changes taking place in the ownership and control of livestock in Minnesota:

D5a. who owns the livestock and livestock facilities and what is the significance?,

D5b. what are the current trends in type of ownership by animal species, facility size and regional location?

D3e. How are livestock businesses different from and similar to non-agricultural businesses with respect to the following factors, and what are the implications of these differences: patterns of ownership and control

It is not clear what classification of owners is of interest to these questions. USDA tracks the share of farmland owned by foreigners. Comments we have heard about absentee ownership of livestock operations suggest that classifying owners by local community of residence might be of interest. On the other hand, the Minnesota Corporate Farming Law differentiates between Minnesota farmers and others, suggesting that a classification based on state of residence and principal occupation might be of interest.

It might be useful to broaden the discussion of control from control of livestock in Minnesota to control of the food system generally, since the economic environment faced by Minnesota livestock operations is likely to be affected by changes taking place throughout the global food system.

D5d. who makes the decisions over the practices of livestock operations of different kinds in Minnesota (owners vs. renters)?

We were not sure how to address the "owners vs. renters" dichotomy in this question. In the late 1970s, several studies addressed the question of whether rented cropland was being as well protected from soil erosion as owner-operated cropland was. A quick search did not turn up any publications on this question more recent than about 1985, so it appears that interest in this topic appears to have declined. None of the publications seemed to focus specifically on livestock operations, in any case, so we will not cite them here. The "renters" category seems less relevant to livestock issues than it does to crop issues. In livestock production, it would seem that a more relevant dichotomy might be something like:

- independent producers vs.
- producers with production contracts (own facilities but not the animals) and their contractors vs.
- owners of larger operations, managers, and their employees who do not have an investment in the operation.

Question E2b. What are the comparative internal economic costs and benefits of various livestock production systems?

One issue that is not specifically in the GEIS questions is the impact of possible higher future energy prices on the ways livestock is produced and marketed. This is a question that often comes up in discussions about the future of agriculture. There seems to be a perception that

confinement systems are less energy-efficient than alternatives, and that higher energy prices would force changes. Our impression is that confinement systems are relatively feed-efficient, and that when energy requirements for feed production are considered, they might not necessarily be less energy-efficient overall, but we are not aware of any recent research that addresses the question adequately. This is a possible topic for future research.

Question E1. What are the economies of scale (including diseconomies) related to livestock raising, and what are the implications for size and type of production system?

A clarification of terminology - Economies of size and scale are often used interchangeably, but they are somewhat different concepts. *Economies of size* relate to the reduction in average total cost associated with varying levels of output, where the proportional relationship between production resources is not held constant. In other words, as farms get bigger, the relative proportions of land, labor, and capital typically change. *Economies of scale* relate to proportionate increases in all production resources as output increases. For most farm situations, "economies of size" is a more commonly used concept, in that resource ratios typically change as farms become larger. We will assume that economies of size are what are of interest to the GEIS.

One point that needs to be kept prominent in the discussion is the fact that increasingly, livestock businesses operate with *multiple locations* under *one business entity* or firm that controls the multiple locations through direct ownership, contracts or other business arrangements. In a multi-location livestock operation, size can be calculated based on the number of livestock at the same location or the number controlled by the same firm. For some environmental issues such as volume of a potential manure spill, the location size seems most relevant. For other issues such as market power, the firm size is probably what matters.

One general comment about topic E is that the introduction to the topic mentions economies of scale and government policies, but does not explicitly ask the question of how government policies, and especially federal commodity programs, may influence economies of scale or have a "large farm bias."

Question E2. How is the profitability and economic viability of farms and firms affected by different production and marketing arrangements? What are the comparative internal economic costs and benefits of various livestock production systems?

Question E2a. How is the profitability and economic viability of farms and firms affected by different production and marketing arrangements?

There are obviously many different production and marketing arrangements in use in livestock production. In responding to this question with respect to an individual livestock operation, it is necessary to make assumptions about the rest of the industry. A bit of Economics 101 - Generally speaking, at any point in time in any industry made up of more than one firm, the different firms operate at different levels of efficiency, profitability, and risk. They compete, and over time the more profitable firms expand and drive down prices while the less profitable firms shrink or gradually leave the industry. This scenario assumes that all firms produce an identical, generic commodity and sell it in a perfectly competitive market.

The impact of different production and marketing arrangements on the profitability and economic viability of a particular, representative farm will depend on how broad the adoption of the arrangement is in the rest of the industry. Increasingly, it is becoming more feasible to produce agricultural products with specific characteristics that may bring different prices when marketed though "niche" marketing channels. Over time, livestock operations, like other businesses, tend to adopt the most promising new arrangements. The "treadmill hypothesis" states that the early adopters reap higher profits for awhile when they adopt, but when the rest of the industry adopts then profits return to normal levels. Any particular production or marketing arrangement aimed at a niche market may provide high returns to the first few farms that get into it, but the market may become saturated quickly so that later adopters may suffer losses under the same arrangement.

Critical Review of Information Sources

Topic D covers the dimensions of the Minnesota livestock industry, including the numbers, locations, and nature of feedlots; the business structures used by livestock operations; the ownership and control of livestock operations; the present market situation; and the competitiveness of Minnesota livestock producers in national and international markets.

Topic E covers the profitability and overall economic viability of both livestock farms and livestock processing firms including how they are affected by such factors as economies of scale, production methods, marketing arrangements, and government policies and programs. Livestock processing firms are discussed above under question D4, so the discussion under topic E questions will focus on farms.

Question D2. With respect to the following factors, what is the current situation in the Minnesota livestock industry, what are the changes taking place, why are the changes occurring, and what are their implications:

a. geographic distribution, and

b. size of enterprise

General Livestock Industry Trends

Farm structure discussions frequently cover aspects such as (Quiroga 1991):

- Number and size of farms: Total number of U.S farms peaked in 1935, 6.8 million farms, and has declined to 2.1 million in 1993. Average acres per farm increased from 155 acres in 1935 to 456 acres in 1993.

- Concentration: Seventy three percent of the farms were non-commercial (sales less than $50,0000) in 1993 and accounted for 10 percent of the production. Farms with sales of $1 million or more made up 0.7 percent of the farms but accounted for 26 percent of the gross sales. Four percent of farms produced half of the gross sales. Thirteen percent produced 75% of the gross sales. Seventeen percent of the farms produced 50% of the gross sales in 1900 compared to 4 percent in 1993.

- Tenure: Most operations were full owners in 1993, but part owners and tenants had larger farms. Tenure differs by sales class, with commercial farms less likely to be full owners. Land leasing has changed from a way for beginning farmers to enter agriculture to a way of gaining access to additional assets. This allows farmers to avoid debt and risks associated with ownership, and to be able to respond more quickly to changing market conditions.

- Legal Organization: Most U.S. farms are organized as single proprietorships, but partnerships and family corporations tend to be much larger. Partnerships made up only 6 percent of the U.S. farms in 1993 but accounted for 16% of the gross sales. Family and non-family corporations were 3 percent of the farms but had 18% of the gross sales.

- Contracting: Farmers have become more reliant on production and marketing contracts over the past 40 years. Eleven percent of U.S. farms had at least one marketing contract, but these farms accounted for 40 percent of the gross sales.

- Operator Characteristics: Full time commercial farms made up 21 percent of all farms, but accounted for 76 percent of the value of gross sales. Forty five percent of all farm operators reported farm or ranch as their major occupation in 1993, operated 73 percent of the land and had 82% of the gross sales. Retired operator accounted for a substantial proportion of all farms but produced relatively little.

- Operator households: Farm operator households typically receive income from several sources, and 88% of their household income came from off the farm in 1993. The relative importance of off-farm income varies widely among different farm types.

Recent trends in the Minnesota livestock industry are shown in Table 1. Cattle and sheep numbers are down in the state. Numbers of sheep and lambs are down by almost a third since 1993, although the inventory last January has started to rebound with a 6 percent increase. Cattle on feed has also rebounded a bit this winter, which would be expected given the low feed prices. Beef cow numbers seem to be on a fairly steady downward slide over the period. Dairy cow numbers slid by seven percent in 1997. They continued to decline in 1998 but the rate of decline was less, down two percent for the year.

The sectors that have shown growth since the early 1990s are hogs, layers, and turkeys. Perhaps the big story is hogs -- there were 21 percent more hogs and pigs on Minnesota farms last December, compared to December 1992. The pig crop was also up 8 percent in 1998. The inventory numbers had leveled off by December 1998 (shown in the 1999 column). The upward trend in hog numbers can be expected to level off and perhaps reverse itself as producers liquidate in response to the current disastrously low hog prices.

Turkey production has grown since the early 1993, but appears to have leveled off in the past year. The number of laying hens is also up by 1.3 million. The Golden Oval operation in Renville County is at around two million hens, so it would appear that the rest of the egg industry is pretty static.

Consolidation of livestock production onto fewer farms is probably not news to very many people, but the trend is very evident in the hog and dairy farm numbers. The number of

operations with hogs has declined almost 40 percent since 1993. Dairy operations are also down, by 28 percent. Not much change is evident in the number of cow-calf operations, while the number with cattle on feed is down eight percent. The information on the number of sheep operations is not out yet for this year, but was down substantially as of a year ago.

Table 1. Changes in the Minnesota Livestock Industry, 1993-99

Species	1993	1997	1998	1999	1993-97	1997-98	1998-99	1993-99
	number of animals (000)				Percent			
Inventories and Production:								
All sheep & lambs, 1/1 inventory	245	180	165	175	-27%	-8%	6%	-29%
All cattle, 1/1 inventory	2,849	2,800	2,500	2,500	-2%	-11%	0%	-12%
Cattle on feed, 1/1 inventory[a]	330	300	265	270	-9%	-12%	2%	-18%
Beef cows, 1/1 inventory	410	405	395	385	-1%	-2%	-3%	-6%
Milk cows, 1/1 inventory	660	595	555	545	-10%	-7%	-2%	-17%
All hogs and pigs, prev. 12/1 inv.	4,700	4,850	5,700	5,700	3%	18%	0%	21%
Pig crop, annual	8,618	8,873	9,612		3%	8%		
Turkeys raised, annual	42,000	45,500	44,500		8%	-2%		
Laying hens, annual average	10,731	11,712	12,032		9%	3%		
Broilers raised, annual	46,600	46,300			-1%			

Operations with:	1993	1997	1998	1993-97	1997-98	1993-98
	Number operations			percent change		
Hogs	14,000	9,000	8,500	-36%	-6%	-39%
All cattle and calves	38,000	33,000	31,000	-13%	-6%	-18%
Milk cows	13,500	10,500	9,700	-22%	-8%	-28%
Beef cows	16,000	16,000	15,800	0%	-1%	-1%
Cattle on feed	8,000	7,500	7,400	-6%	-1%	-8%
Sheep	4,800	3,000		-38%		
All farms[b]	87,000	87,000		0%		

Sources: (Anonymous various issues), (Anonymous various issues), (Anonymous various issues), (Anonymous various issues), (Anonymous various issues), (Anonymous various issues), and (Anonymous various issues)

[a]Cattle on feed are animals for slaughter market being fed a ration of grain or other concentrates and are expected to produce a carcass that will grade select or better.

[b]A farm is any establishment from which $1,000 or more of agricultural products were sold or would normally be sold during the year.

More Details on Trends in the Dairy Industry

The structure of the Minnesota dairy industry has experienced dramatic changes in productivity, herd size growth, reduction in total cows and herds, and a dramatic reduction in the number of milk processing plants. Historically, milk sales have been the largest generator of farm income in the state, ranging between 18 and 22 percent most years. It still was in 1998 when sales of cull cows and calves are combined with milk sales. Nationally there has been a shift in the regional market share where milk is produced (Table 2). The national market share of milk has declined from 8.3 percent in 1960 to 5.9 percent in 1998. (Conlin 1995b; National Agricultural Statistics 1999) Minnesota has dropped in ranking from third in 1960 to fifth in 1998.

Table 2. Shifts in Percent of U.S. Milk Production

	Percent of U.S. Market Share						
	1998	1993	1991	1987	1984	1973	1960
California	17.5	15.2	14.5	12.5	11.3	8.7	6.6
Wisconsin	14.5	15.2	16.2	17.4	17.4	16.3	14.4
New York	7.5	7.6	7.5	8.0	8.4	8.5	8.4
Pennsylvania	6.9	6.8	6.8	7.1	7.0	5.8	5.6
Minnesota	5.9	6.4	6.6	7.3	7.6	8.0	8.3
Idaho	3.7	2.1	2.0	1.7	1.6	1.4	1.3
Texas	3.6	3.9	3.6	3.0	2.8	2.8	2.4
Michigan	3.4	3.6	3.5	3.7	3.9	4.1	4.2
Washington	3.4	3.3	3.0	2.6	2.6	2.0	1.7
New Mexico	2.8	1.8	1.3	.7	.7	.3	–
Ohio	2.8	3.1	3.2	3.4	3.4	3.8	4.2
Iowa	2.4	2.7	2.8	2.5	2.8	3.5	4.8
Arizona	1.7	1.2	1.2	1.0	.9	.6	–
Vermont	1.7	1.7	1.6	1.7	1.6	1.7	1.6
Florida	1.5	1.7	1.7	1.6	1.4	1.6	1.1
Missouri	1.5	1.9	1.9	2.0	2.0	2.6	3.0
Indiana	1.4	1.5	1.5	1.6	1.7	2.0	–
Illinois	1.3	1.7	1.9	1.9	1.9	2.4	3.4
Virginia	1.2	1.3	1.4	2.6	1.5	1.5	1.6
Colorado	1.1	1.0	.9	.8	.7	.7	–
Kentucky	1.1	1.4	1.5	1.6	1.6	2.1	2.6
Kansas	1.0	0.7	0.8	0.9	0.9	1.3	1.5
Oregon	1.0	1.1	1.1	1.0	1.0	.9	–

Minnesota's share of the national market has slipped in the past 28 years.

Sources: USDA Economic Research Service, Dairy Situation, March 1985-92.
USDA Agricultural Marketing Service, Dairy Market News, Vol. 55, Rep. 10, 1988.
USDA Economic Research Service, Dairy Outlook, February 23, 1988.

Adapted from: USDA, NASS, http://usda.mannlib.cornell.edu/re...ssr/dairy/pmp-bb/1999/mkpr0299.txt

The greatest gains in market share have come in the Western states of California, Washington, Arizona, New Mexico, and Idaho. California has increased its market share by a factor of more than 2.5 since 1960 and is still growing. Pennsylvania, Michigan, and Vermont are the exceptions in the Northeast and Midwestern regions in that they have tended to hold their market share. States losing market share have been in the more traditional dairy areas - Wisconsin, Minnesota, Iowa, Illinois, Ohio, New York, Missouri, and Kentucky. The reasons for these shifts are not well documented in the literature but there is evidence of differences in the average cost of production (Table 10 below), productivity ((Anonymous various issues)) herd size (Table 3), use of technology, level of specialization, and mode of operation. These traditional areas tend to be made up of herds less homogenous in the way they are managed and operated but typically have smaller herd sizes, and more diversified operations that grow a major portion of the feed supply that is marketed as milk.

Minnesota reached a peak of 151,064 dairy farm in 1945. More than 80% of the farms sold milk. Dairy herd numbers were at 9,514 in 1998 or 12% of the farms. Cow numbers have dropped from a high in 1945 of 1,660,000 to 551,000 in 1998. The dairy cow density on agricultural land has sharply decreased from 19 acres per cow in 1945 to 54 acres per cow in 1998. Herd size has increased from 11 to 58 cows per herd between 1945 and 1998. The number of small and medium herd size categories are decreasing most rapidly and the two largest herd size categories, above 200, cows are increasing in number in the 1990s'. The average herd size nationally is 79 cows per herd. Table 3 documents the herd size profile of Minnesota dairies with other major milk producing states and state that have been increasing their market share.

Table 3. Herd Size Profile Percent Inventory by Size Groups for Selected States – 1998

	1-29	30-49	50-99	100-199	200-499	500+
			Percent of total cows			
California	--	--	--	3	18	78
Wisconsin	5	21	43	18	10	3
New York	3	11	34	26	15	12
Pennsylvania	5	25	37	22	10	2
Minnesota	6	22	40	16	12	4
Michigan	5	11	25	32	18	10
Idaho	1	2	6	12	19	61
Washington	--	1	4	16	32	47
New Mexico	--	--	--	1	3	96

Productivity per cow has increased three fold between 1945 and 1998, producing 17192 lbs. milk per cow annually nationally in 1998 compared to 16833 lbs. per cow in Minnesota. Minnesota ranks 16th nationally in production per cow. Washington ranks number one in productivity at 21,476 lbs. milk per cow annually (Anonymous various issues). Minnesota DHIA reports that more than 1,325 herds in the state are producing more than 20,000 lbs. per cow. (Minnesota

Dairy Herd Improvement Association 1999). Total milk produced in the state peaked at 10.8 billion lbs. in 1985 and dropped to 9.2 billion lbs. in 1998.

The concentration of dairy cows in the state has changed drastically since 1945 with one cow for every 19 acres of agricultural land to one cow for each 54 acres in 1998. Minnesota produces more than 2,000 lbs. of milk per person in the state or 3-1/2 to times the average consumption (Table 4). Only about 15 to 18% of the total milk produced is consumed as fluid milk; most is processed into manufactured dairy products, like cheese, dry milk and butter and ice cream. Almost 70% of Minnesota's milk was made into cheese in 1997 with a rapid rise in Italian cheese production since 1993. This is in contrast to Minnesota's national leadership in butter, dry milk powder, and ice cream production in the 1970's and early 1980's. This required an industry conversion to cheese in response to changing consumer demands. (Minnesota Department of Agriculture 1998; Conlin 1995b). Minnesota ranked fourth nationally in cheese production in 1998 and fifth in butter processing (Anonymous various issues).

Table 4. Minnesota's Changing Dairy Landscape

Year	Dairy Farms (thousands)	% Farms Marketing Milk	% Grade A	Dairy Cows (thousands)	Cows/ Herd	Ag land per cow (acres)	Milk LB/Cow
1945	151	80	--	1,660	11	19	5,186
1955	116	70	4	1,378	12	23	6,410
1965	67	47	8	1,232	18	25	8,550
1975	33	28	26	884	26	36	10,119
1985	22	23	47	915	41	34	11,800
1993	13	15	72	648	49	46	15,000
1998	9.5	12	92	551	58	54	16,833

Geographic shifts have also been occurring within the state where most of the milk is produced. Minnesota's dairy belt has ranged from the Southeast: Houston and Fillmore counties, up through Winona, Goodhue, Wabasha, Rice, Carver, Wright, Stearns, Morrison, Todd, Ottertail and Becker Counties. The top five milk producing counties are Stearns, Ottertail, Winona, Morrison, and Goodhue. Over time, the exodus from dairying has been more pronounced outside of this region resulting in a greater geographic consolidation. (Conlin 1995b)

Professor Joe Conlin, a University of Minnesota extension dairy scientist working with the dairy industry since 1968, characterized some of the changes taking place in the Minnesota dairy industry over time. See Table 5, based on agricultural statistics available from the Minnesota Department of Agriculture. (Conlin 1995b)

Table 5. Dairying's Contribution To Farm Income					
Year	Gross Farm Milk Income ($ thousands)	% Total Farm Income Dairying	Average Price $/cwt	State Total Milk lb. (billions)	No. Minnesota Butter & Cheese Plants
1945	184	20	2.70	8.6	845
1955	247	19	3.12	8.8	625
1965	348	22	3.34	10.7	327
1975	687	15	7.68	8.9	86
1985	1,026	21	12.05	10.8	44
1993	1,229	18	12.67	9.7	27
1998	1,362	16	13.19	9.2	20

He identified ten major trends that are underway in the dairy industry (Conlin 1995b):

1) Dairy farms are restructuring to larger, more specialized farms that are multi-person owned and operated, on a relatively smaller land base with greater vertical integration with the market and input sectors, and more diversity in size and production processes.

2) Higher priority given to management goals: efficiency, profitability and life quality with higher productivity per unit of labor, feed, and asset, more emphasis on effective management of people, adoption of cost effective technologies, use of outside expertise and greater systemization, routinization and specialization of production tasks.

   a) Implementation of quality management concepts such as management information systems, strategic and tactical business plans and action protocols, team work, and monitoring and control systems.

   b) Increased business networking and collaboration through joint ownership, creative financing and risk sharing, leasing arrangements, closer linkages between production and consumption, more outsourcing operational phases, and greater use of external advisors.

3) Greater price volatility with less government involvement in regulating prices of feed and milk, and expanding potential for export pressures and greater use of price risk tools such as futures, options, and contracts.

4) Stronger consumer driven markets with more emphasis on quality defined in human health/safety risks, consumer tastes, packaging and product preferences, with growing competitive opportunities in international markets and niche markets and product differentiation.

5) Restructuring of the dairy industry business/service sector with mergers, and consolidations having fewer processing plants, greater privatization of information, globalization of technology and services, with a feed industry becoming more price driven with greater use of commodities, and separation of consulting services from product sales.

6) Changing public policy with markets being more driven by supply/demand and quality, less regulation of pricing policies, broader public input on agricultural policy, particularly issues related to the environment, food safety, and animal care. The dairy business will be more sensitive to broad government policies related to taxes, interest rate, environment, health, trade, crop programs, etc.

7) Stricter environmental protection policies related to protection of ground water and air quality that will bring greater integration of manure application with the cropping and land characteristics.

8) Cow numbers will shift to regions that have dairy friendly communities with plentiful supplies, cost competitive feed and services, with a desirable climate, infrastructure of dairy support services and markets, and where there is access to capital.

More Details on Trends in Other Livestock and Poultry

Table 6 shows percentage shifts in market share for the top ten states and Minnesota (if not one of the top ten) for selected years since 1970. Minnesota has been losing market share in beef cow-calf and cattle feeding operations, while our pork industry share is increasing. While the state's sheep numbers in absolute terms are down (see Table 1), so are national inventories so that in percentage terms our market share is fairly stable. Our poultry market share has also been stable in the 1990s. One question that has been raised is whether there are any examples of states where livestock production was declining in terms of market share vs. other states, and had turned around and is growing today. Missouri and Oklahoma's increases in hog inventories since 1991 are two example turnarounds that stand out. Wyoming's market share in sheep inventories also increased in 1998, but they actually lost inventories in absolute terms, just not to the extent that other states did.

Table 6. Shifts in State Market Shares of U.S. Livestock and Poultry Production

Beef cows, 1/1 inventory

	1998	**1995**	**1992**	**1990**	**1985**	**1980**	**1975**	**1970**
TX	16.4	17.1	16.2	15.7	15.8	15.1	15.2	15.3
MO	5.9	6.0	6.1	5.9	5.7	6.1	6.1	5.2
OK	5.8	5.6	5.7	5.7	5.6	5.8	6.0	5.8
NE	5.7	5.4	5.2	5.3	5.1	5.3	5.2	5.0
SD	4.6	4.7	4.5	4.5	4.6	4.1	4.7	4.6
MT	4.6	4.4	4.3	4.0	4.3	3.8	3.7	4.3
KS	4.3	4.3	4.0	4.2	4.3	4.6	4.3	4.9
KY	3.4	3.3	3.3	3.1	2.9	3.0	3.1	2.9
FL	3.0	3.2	3.2	3.3	3.3	3.2	3.2	2.4
IA	2.9	3.0	3.4	3.4	3.7	4.7	4.0	3.9
MN	1.2	1.2	1.1	1.1	1.2	1.5	1.6	1.4
Other	42.2	43.0	44.3	44.9	44.7	44.3	44.4	45.7

Table 6 continued

Cattle on feed, 1/1 inventory

	1998	1996	1993	1991	1986	1981	1976	1971
TX	21.0	20.6	19.4	18.3	18.7	15.8	14.6	11.6
KS	17.4	17.3	15.1	13.8	12.5	9.5	10.4	7.2
NE	16.9	15.9	16.8	18.2	16.6	14.1	10.8	11.1
CO	8.4	8.4	7.9	7.9	8.2	7.3	7.2	6.8
IA	7.3	5.7	7.0	8.2	5.9	11.8	11.8	15.6
OK	3.2	3.2	2.7	2.6	2.8	2.8	2.2	1.9
CA	2.9	2.7	3.5	3.5	4.0	5.8	7.4	7.8
SD	2.3	2.6	2.7	2.5	3.1	3.1	2.8	2.7
ID	2.2	2.1	2.2	2.0	1.8	2.1	1.6	1.7
MN	2.0	2.6	2.6	2.7	2.6	3.2	3.3	4.3
Other	16.3	18.9	20.2	20.3	23.8	24.5	27.9	29.3

Hogs and pigs, 12/1 inventory

	1997	1994	1991	1989	1984	1979	1974	1969
IA	23.4	24.2	26.0	25.1	26.3	24.1	24.3	24.6
NC	16.2	11.7	6.3	4.8	4.3	3.9	3.4	2.8
MN	9.0	8.1	8.5	8.3	8.0	7.3	6.7	5.5
IL	7.9	8.9	10.2	10.6	10.0	10.3	11.8	11.6
NE	5.9	7.3	7.8	7.8	6.8	6.2	5.5	5.0
MO	5.8	5.8	4.7	5.0	6.4	6.9	7.1	7.4
OK	2.7	1.0	0.3	0.4	0.4	0.5	0.6	0.7
OH	2.7	3.0	3.3	3.9	3.6	3.1	3.5	4.5
KS	2.4	2.2	2.5	2.7	3.0	3.1	3.2	2.9
SD	2.1	2.9	3.4	3.2	3.0	3.0	3.1	3.0
Other	21.8	25.0	26.9	28.3	28.4	31.6	30.7	32.0

Breeding sheep and lambs, 1/1 inventory

	1998	1995	1993	1990	1985	1980	1975	1970
TX	21.1	21.0	21.9	19.7	18.9	20.3	20.0	19.6
WY	9.2	8.4	8.6	7.3	8.4	8.7	9.6	9.8
CA	7.9	8.4	7.7	8.1	9.8	9.0	7.3	6.8
MT	7.0	7.0	6.3	6.7	5.3	5.1	5.0	6.2
SD	6.0	6.3	6.0	5.6	6.4	6.5	5.8	5.8
UT	5.7	5.6	5.4	5.1	5.5	5.4	5.3	5.6
CO	4.3	3.9	4.5	4.7	4.2	4.6	4.4	4.7
ID	4.2	3.7	2.8	2.8	3.3	4.1	4.5	3.6
NM	3.9	4.1	4.6	4.9	5.5	5.4	4.4	4.5
OR	3.2	3.8	3.9	3.6	3.9	3.5	2.9	2.6
MN	2.0	2.2	2.2	2.2	2.1	2.0	2.4	2.4
Other	25.5	25.8	26.1	29.4	26.6	25.5	28.3	28.2

Turkeys raised, annual

	1996	1994	1992	1990	1985	1980	1975	1970
NC	20.3	20.6	20.9	19.2	16.1	12.9	10.6	8.1
MN	13.2	12.8	12.8	14.1	14.2	13.7	16.2	16.9
MO	8.1	7.2	6.8	6.0	6.6	7.4	6.7	7.3
AR	7.3	7.7	8.2	7.5	8.0	8.5	5.9	6.5
CA	6.9	6.8	7.9	12.0	11.5	13.5	13.2	13.9

Table 6 Continued

VA	6.6	6.2	5.7	5.2	6.6	5.5	4.4	3.5
IN	4.9	5.1	5.5	4.8	3.5	3.7	3.7	4.3
SC	3.6	2.6	3.1	2.8	2.2	2.8	2.7	2.7
PA	3.4	3.1	2.8	2.8	3.6	3.0	2.4	2.0
OH	3.2	2.7	2.3	2.2	1.9	1.6	2.4	3.4
Other	22.5	25.2	24.1	23.5	25.8	27.4	31.8	31.4
Broilers raised, annual								
	1996	**1993**	**1991**	**1989**	**1984**	**1979**	**1974**	**1969**
AR	15.5	15.1	15.5	16.1	16.2	16.2	15.3	14.0
GA	15.5	14.4	14.0	14.9	14.6	13.7	14.0	15.4
AL	11.5	13.0	13.8	13.1	17.6	12.1	12.7	12.3
NC	9.7	10.2	9.8	10.2	10.5	9.9	10.1	10.3
MS	8.5	7.9	7.2	6.8	7.2	7.0	7.4	7.7
TX	5.2	5.3	5.5	5.2	4.7	5.7	5.8	5.9
DE	3.9	4.2	4.4	4.7	5.1	4.9	5.2	5.2
MD	3.8	4.4	4.3	4.6	6.4	6.5	6.7	6.8
VA	3.4	3.7	3.6	3.3	3.6	3.1	2.5	2.2
CA	3.2	3.6	4.2	4.4	4.6	3.9	3.4	2.9
MN	0.7	0.8	0.8	0.8	0.7	0.5	0.4	0.5
Other	19.1	17.4	16.6	15.8	8.8	16.6	16.5	16.8

Source: USDA Agricultural Statistics, various years, (Minnesota Department of Agriculture 1998)

Information on the size distribution of swine operations is available from several sources. The USDA National Agricultural Statistics Service publishes data on the number of swine operations and percent of inventory by size in the December 1 Hogs and Pigs reports each year. This is usually the most current source of information, and is based on surveys which appear to be reasonably sound from a statistical standpoint. One drawback of the Hogs and Pigs Report data is that it does not provide much detail on the largest sized operations, since the largest size category is "over 5,000 pigs" in inventory. Another source with more detail is the Census of Agriculture. This includes size breakdowns by number in inventory, number sold per year, and number of litters farrowed per year. The census is probably the most accurate data available, since all farms are enumerated rather than only a sample as with the Hogs and Pigs report. A drawback of the census is that it is only done every five years, so the data is not always as current as with Hogs and Pigs (the latest census was done in 1997, so it is fairly current at this writing). It also is somewhat lacking in detail about the largest size categories, with the largest size categories being "5,000 or more pigs inventory", "7,500 or more pigs sold per year", and "1,000 or more litters farrowed per year."

These three different size measures can be confusing for the casual reader, so care must be taken when comparing different sources to assure consistency of comparisons. For most intensively managed swine operations, the number of pigs sold per year will be greater than the number in inventory at any point in time, since it only takes about six months for a pig to reach market weight. Also, roughly 7 - 10 pigs are typically sold per litter farrowed, depending on the age at sale, death losses, and other factors, so the number sold will be greater than the number of litters farrowed. The numbers are further complicated by the fact that some operations both farrow and

finish the pigs to market weight, while increasingly operations only farrow the pigs and sell or transfer them to others for finishing.

A third source with more detail on the largest operations is a series of annual surveys conducted by researchers at Iowa State University and the University of Missouri. The latest report from this activity is (Lawrence and others undated). The sampling frame is based mainly on the list of subscribers to a swine trade magazine, with complete enumeration of the largest operations. As such, its statistics may not be quite as reliable as the other two sources but is often used because of its additional detail. The size distribution by number marketed (sold) per year is shown in Table 7. It shows that there were 18 operations marketing 500,000 or more pigs per year in 1997, representing 24 percent of total U.S. slaughter.

Their summary of the most recent size trends was:

> "Consolidation of the pork industry is continuing. However, the changes are occurring primarily in the largest and smallest groups of producers. The largest operations are gaining the greatest market share and the very smallest are showing the greatest loss. In 1997, 145 firms marketing 50,000 hogs or more a year marketed approximately 33.1 million head (37% of U.S. produced) of hogs in 1997 (Table 7). This figure compares with 16 million head from 66 firms in that size class in 1994, the last such study completed (Grimes and Rhodes, 1995). This is a dramatic increase in only three years. Another 51.7 million hogs (56%) were marketed by an estimated 23,400 operations selling 1,000-49,999 head a year. The remaining 5% of the U.S. hogs were marketed by approximately 80,000 farms selling fewer than 1,000 hogs annually based on USDA estimate of the number of farms with hogs, December 1997, Hogs and Pigs." (p. 2)

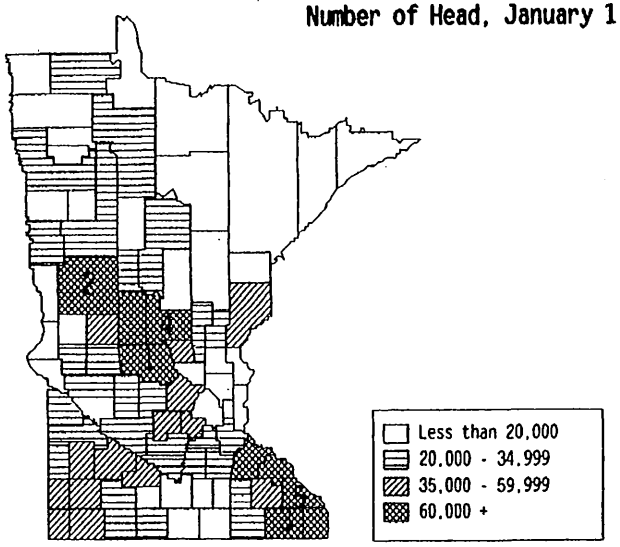
Table 7. Estimated Number of Operations and Share of U.S. Slaughter 1997, by Size Category.

Annual Marketings 1000 Head	Number of Operations	Market Share (%)
<1	80,000	5.4
1-2	11,708	12.1
2-3	4,996	9.7
3-5	3,438	9.9
5-10	1,978	9.9
10-50	1,318	16.2
50-500	127	13.1
500+	18	23.8

Source: (Lawrence and others undated)

ALL CATTLE & CALVES

Number of Head, January 1, 1998

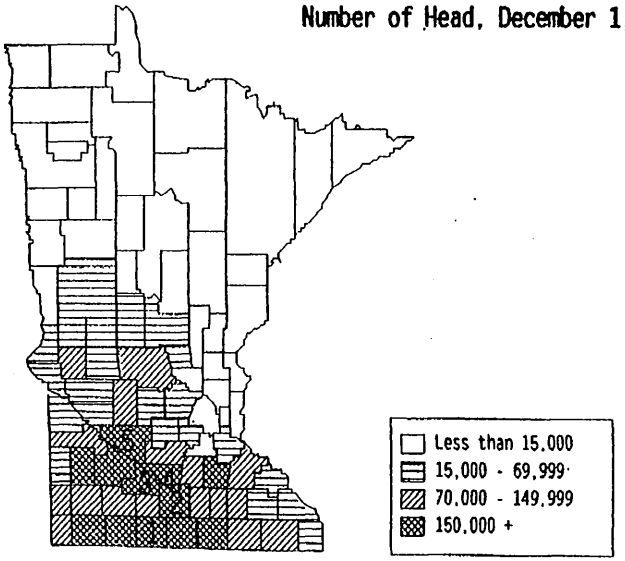


Top Five
All Cattle
& Calves
Counties
For 1997

1-Stearns
2-Otter Tail
3-Fillmore
4-Morrison
5-Winona

ALL HOGS

Number of Head, December 1, 1997

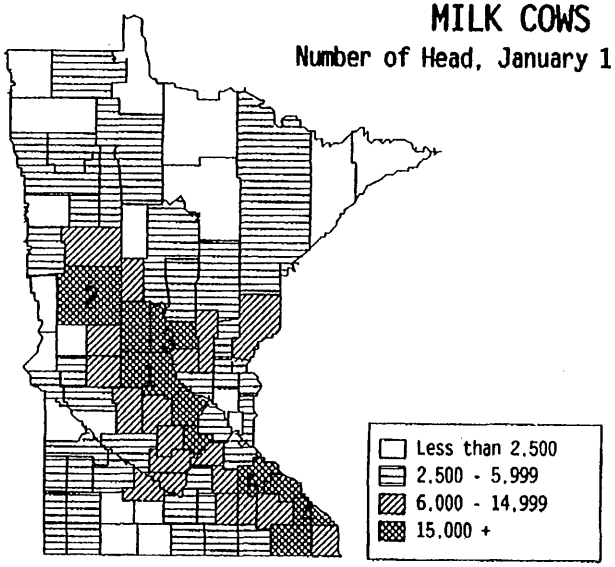


Top Five
All Hogs
Counties
For 1997

1-Martin
2-Blue Earth
3-Brown
4-Nicollet
5-Renville

MILK COWS

Number of Head, January 1, 1998

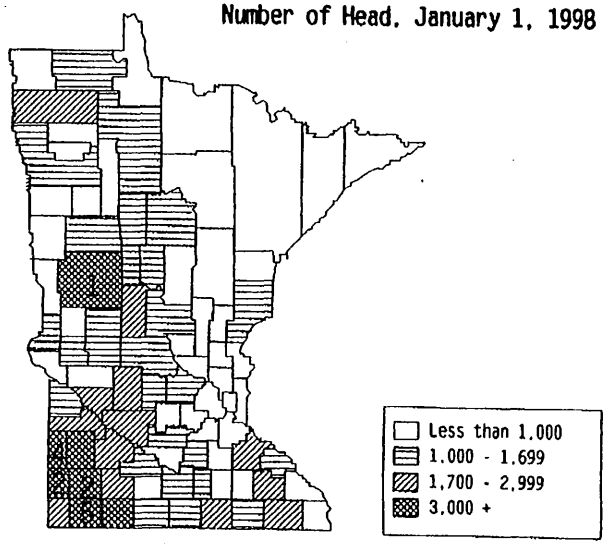


Top Five
Milk Cows
Counties
For 1997

1-Stearns
2-Otter Tail
3-Morrison
4-Winona
5-Goodhue

ALL BREEDING SHEEP & LAMBS

Number of Head, January 1, 1998



Top Five
All Breeding
Sheep &
Lambs
Counties
For 1997

1-Otter Tail
2-Murray
2-Pipestone
4-Lincoln
5-Nobles

c. type of business organization and degree of vertical integration or coordination

One source of information on type of business organization is the Census of Agriculture, which gives a breakdown of the number of sole proprietorships, partnerships, and corporations (Anonymous 1998c). All farms are lumped together in the statistics, rather than having a separate breakdown just for livestock operations. Corporations with more than ten shareholders made up only 0.3 percent of Minnesota farms in 1997, and accounted for 4.2 percent of the market value of products sold.

It would be possible to measure vertical integration or coordination such as, in hogs, packer control of production through ownership of production facilities, marketing contracts, or production contracts. Feed or genetics suppliers may exercise a certain degree of control of production through ownership or contracts. Veterinarians and other information providers may be involved in production decisions to some degree.

According to a February 1999 survey of nine the largest twelve pork packers, 64 percent of the slaughter hog purchases during January 1999 were priced under some contractual method other than the spot market (Anonymous 1999). This was an increase from 57 percent in 1997. Formula price contracts tied to the spot market amounted to 44 percent of sales, so that the spot market determined prices for 80 percent of the hogs which is down only slightly from the 82.5 percent found in the 1997 survey. About 18 percent of the hogs were purchased under some system that supposedly reduces price risk to producers, but the amount of the risk reduction is unclear because many of the contracts involve ledger balances which may have to be repaid later in the life of the contract. When the authors state that the spot market determined prices of hogs sold under formula prices, we believe that they are speaking of daily price movements over the short run. As one reviewer points out, over the longer run, increased use of marketing contracts may cause thinning of the spot market. As the spot market thins, the hogs sold on the spot market may become less representative which could frustrate price discovery. This topic is discussed further under section D4f, "price discovery and market fairness."

Production contracting may not initially be thought of as falling under "contractual buying and selling arrangements," but it does involve buying and selling the farm operation's labor, facility and other services, so will be mentioned here. The latest figures on the level of production contracting in the swine industry is from the 1998 Industry Structure Study by Glenn Grimes, University of Missouri and John Lawrence, Iowa State University (Miller 1998). They found that 17 percent of 1997 slaughter hogs were farrowed under contract, and 30 percent were finished under contract. They also looked at when currently held contracts were signed. The largest sign-up was in 1997. Most contracts are set to expire at a fairly even rate between now and the year 2007. Production contracting is the norm in the poultry industry, with 85 percent of broilers grown under contract in 1995. Most of the remaining chickens are grown on farms owned and operated by the integrator (Perry and others 1999).

No research-based studies were found on milk marketing contracts. Most milk is marketed through farmer cooperatives with informal marketing arrangements that producers can change processors at relatively short notice. Upper Midwest milk processors are currently in highly competitive with each other to secure producer milk to maintain plant-processing efficiency in

the face of a declining supply. The authors are aware of several incentives processors are using to compete for producer milk such as quality premiums, discounts on hauling charges, management services, volume premiums, and various forms of formal milk contacts. The extent to which milk contracts are used is not available. Little is known about the terms of these contracts in that they are proprietary and are confidential between the producer and processor.

Vertical coordination has been described as a continuum of vertical governance structures, variable in the extent to which one party of a vertical exchange prescribes the behavioral pattern of another (Henderson and Frank 1998). Henderson and Frank review the literature on quantifying vertical coordination and vertical integration, and discuss the measurement difficulties involved. They show upstream vertical coordination indices for 38 different U.S. food-manufacturing industries for 1982. They find that, for example, ice cream and frozen desserts have an index of 0.999, while animal fats and oils are at 0.009. Some other industries of relevance to the GEIS are processed egg products, 0.771; fluid milk, 0.543, and fresh meats, 0.528.

Related comments including a discussion of the USDA Packers and Stockyards study of packer concentration and vertical coordination in the swine industry is included under question D4 below.

Hoards Dairyman compiles an annual summary of milk volume and membership of the top fifty milk cooperatives in the U.S (Mowrey 1998). In 1998, the top fifty milk cooperatives in the U.S. ranked on volume of milk accounted for 120 billion pounds of the national production of 157 billion pounds in 1998. They claimed 70,820 member dairy farmers. The ranking of the largest cooperatives has had some major shifts in the most recent years because of mergers. These shifts are expected to continue with very recent mergers and merger discussions in progress. The ten milk cooperatives with largest milk volume accounted for half of total 1998 U.S. milk production:

Dairy Cooperative	**Member Milk (bil. pounds)**	**Number Members**
Dairy Farmers of America, Springfield, MO	31,500	18,453
Land O Lakes Inc., St. Paul, MN	7,988	6,400
California Milk Producers, Artesia, CA	6,750	336
Foremost Farms USA, Barb, WI	5,400	5,850
Family Dairies, Madison, WI	5,256	7,625
Darigold Farms, Seattle, WA	5,050	878
Dairylea Cooperative Inc., Syracuse, NY	4,886	2,369
North Central AMPI, New Ulm, MN	4,400	5,000
Dairymans Cooperative Creamery Assn., Tulare, CA	4,212	245
Manitowoc Milk Producers Cooperative, Manitowoc, WI	3,540	3,230

The second-ranked cooperative, Land O Lakes, has merged with ninth-ranked Dairymans Cooperative Creamery Association since these 1998 figures were compiled.

Lessons from Structural Change in the Broiler, Fed Cattle, and Processing Vegetable Sectors in the 1950s and 1960s

The GEIS study questions seem to be focused primarily on the present situation, but as one reviewer points out, there may be valuable lessons that can be learned from the changes that the broiler, fed cattle, and processing vegetable sectors went through in the 1950s and 1960s. That transformation has been described as a four-step process (Reimund and others 1981). Forces outside farming trigger structural change, at first to exploit new conditions, and later to manage new risks. New technology, market conditions, and policies lead to 1) technological adaptation, 2) shift to new producing areas, 3) growth and development, and 4) adjustment to risk.

"Industrialization" of the Swine Industry

The swine industry has been undergoing rapid changes in recent years along the lines of the earlier sectors discussed by Reimund et al., that some authors have termed "industrialization." An overview of recent trends and driving forces is included in a chapter of Purdue University's Food System 21 report (Boehlje and others 1997). More detail on specific technologies and their potential to improve profitability is provided in (Anonymous 1995). New technologies and management strategies that are thought to be playing a major role include:

- feeding programs that are closely geared to animal needs during specific growth phases, and that respond more quickly to changes in ingredient availability and cost,
- health-enhancing technologies such as all in-all out rearing and early weaning that may reduce improve performance, dependence on antibiotics, and/or maintain acceptable performance in larger facilities,
- breeding systems which utilize crosses of specialized sire and dam lines to achieve desirable traits, and artificial insemination and related technologies which allow elite lines to be utilized more widely,
- more careful facility design and better information systems to improve throughput of animals from a given investment in land and buildings, and
- networked (cooperative) selling and/or buying among groups of producers, and information sharing among producers and between producers and processors to capitalize on quantity- and quality-based premiums and discounts and identify areas that need improvement.

Government policies and regulations that Boehlje et al. expect to shape the future of the hog/pork industry fall into the areas of:

- environmental regulations,
- animal well-being,
- worker safety, and
- policies regarding concentration, control, market access, and price discovery.

Implications they see for the future include:

- more site-specific micro production management,

- optimization of the supply chain from genetics to the end-user/consumer with better flow scheduling and resource utilization, better quality control, reduced food safety risks, and increased ability to respond to consumer demand for specific attributes,
- continued challenges related to environmental and odor problems which will affect size and location, unless technological fixes are developed,
- an increased role for producer associations that provide services to their members,
- trace-back systems from final product to genetics to quickly and easily identify sources of contamination,
- heightened risk from new sources such as shutdown of large plants or disruption of contracts, globalization, and more specialized production units.
- Decisions concerning new production, processing, and distribution centers will tend to be made in a more coordinated fashion than in the past when they were made relatively independently.
- Technological advances in production and processing could dramatically alter the labor requirements to manufacture pork.
- Pork's competitive position could improve relative to beef and possibly even relative to poultry. Finally, ownership of world pork production and processing could become more globalized with more firms investing across national boundaries.

Another analysis of industrialization of the pork sector is presented by several authors in (Royer and Rogers 1998). The chapter by Rhodes in that book includes a number of suggestions for research on ways to:

- reduce social costs of the changes,
- help smaller operations to remain competitive,
- manage the risks involved in the new industry structure,
- assure legal protections for growers that make sense in terms of efficiency considerations, market and political realities, and mainstream ethics, and
- evaluate the tradeoffs for various current and potential production areas, and develop institutional rules that could greatly reduce social costs.

The chapter by Ginder in the same book characterizes the situation in terms of a bifurcated production channel, with one side being a producer-centered, commodity hog side dominated by independent producers and a few large production contractors, along with a specialty hog side dominated by the industrialized producers with packing and processing facilities.

The future role of cooperatives under a more industrialized agriculture is an issue which has received attention from a number of researchers. (Fulton 1995) and (Cook 1995) discussed the outlook for cooperatives. Fulton concludes that the changes in both technology and society's values (more individualism) are likely to make cooperation more difficult in the future. He argues that many cooperatives have been predicated on creating opportunities for farmers in a world of spot markets, and more direct marketing channels and reductions in output variability

would diminish the opportunities for cooperatives. Cook sees a promising but challenging future for cooperatives that take a more offensive rather than defensive approach, and a number of factors conducive to successful collective action in U.S. agriculture, such as where there is a new market in which existing preferences are unknown, where declining markets exist, where shared risk through relational contracts can be accomplished, or where producers recognize asset-specificity-driven opportunism in the early stages of technology adaptation.

Changes in farm profitability and food demand in recent years have led to a great deal of farmer interest in projects to add value to farm products. (Siebert and others 1997) review some of the risks involved in post-harvest value added investment decisions, especially when the new market level being entered is not thoroughly understood. They suggest an alternative: investing in publicly traded equities (stocks) of investor-owned processing firms. For example, ConAgra, IBP, Hormel or Smithfield Foods might provide investment opportunities for livestock producers who are seeking to capture value added at the processing level. Siebert et al. suggest a formula for calculating the size of the investment needed to achieve a balance between the size of the farm's marketings and the diversification capacity of the value added investment.

Production Networks as a Minnesota Response to Swine Industry Industrialization

A number of Minnesota pork producers became involved in swine production networks in the mid-1990s. Twenty producers interviewed in late 1995 cited a number of specific reasons for joining networks (Koehler and others 1996). Most of the producers were previously producing hogs in individually-owned farrow-to-finish operations. In general, they were all looking for a way to access the technology and systems they saw as necessary to achieve low cost production of the product quality and volume necessary to be competitive in the future. Within that general theme, some people emphasized product quality while others focused on volume or labor simplification. The types of arrangements ranged from small-scale, informal farmer-to-farmer formula pricing arrangements to large-scale, jointly owned sow units directed by hired management consultants. Perceived advantages to network participation included:

- disciplined pig flow and larger pig group size that made all in-all out finishing work better, which in turn made it easier to achieve pig health goals
- the opportunity to utilize specialized facilities with modern technology and better working conditions
- the opportunity to utilize staff with specialized skills and expertise
- discounts on input purchases due to quantity purchasing

Perceived disadvantages included:

- the difficulty of arriving at an equitable sharing of profits among the producer-members of the network who might now be involved only in farrowing, only in finishing, or in other parts of the network rather than owning and being in control of the entire system as in a traditional farrow-to-finish operation
- more possible points of risk exposure because more people and facilities are involved in the larger networked system

- increased transportation requirements to move pigs from farrowing to the nursery, and then on to finishing facilities that are be located on different farms

d. competitiveness in national and international markets

Competitiveness can be evaluated by comparing US numbers against selected major competing livestock-producing countries, comparing Minnesota against selected other states, and comparing counties or multi-county regions within the state.

Pork Competitiveness

(Drabenstott 1998) addresses the question of whether the US pork industry could lose market share to other major pork producing countries or regions. He summarizes a cost analysis (Martin and others 1998) which shows that the Canadian prairie provinces have the lowest pork production costs of the regions studied, and have a cost advantage over the US western corn belt including Minnesota (Table 8). The analysis is based on a set of budgets originally developed at Purdue University, with input expenses adjusted for price differences across regions. (Drabenstott 1998) also shows that pork production in Manitoba has doubled in the past 12 years (since 1984), a period over which production in Minnesota increased by 12 percent (Anonymous various issues). (McEwan) attributes the Manitoba expansion to the fact that the Manitoba pork industry is highly concentrated in the hands of a few decision-makers who have responded rapidly to low feed prices brought about by the reduction in Canadian grain transportation subsidies. Roughly one-third of the Manitoba pork production is by two feed companies, while one-third is fed by a small number of Hutterite colonies and the remaining one-third is by independent pork producers.

Table 8. Hog Production Costs by Region

Region	Size of operation	
	1200 sow	3000 sow
	(cost per 100 kg in Canadian dollars)	
U.S. West Corn Belt	88.67	84.44
U.S. East Corn Belt	89.99	85.27
U.S. South East	98.36	93.78
U.S. Mountain	104.15	99.24
Maritime Provinces	104.26	100.08
Quebec	101.22	96.82
Ontario	87.23	81.93
Eastern Prairie Provinces	74.06	69.78
Western Prairie Provinces	84.08	79.30
Argentina	104.64	101.55
Chile	107.96	105.10
Netherlands	143.24	137.16
Denmark	142.95	136.37

Source: (Martin and others 1998), George Morris Centre at University of Guelph

(Drabenstott 1998) also argues that Argentina and Brazil could expand pork production substantially in the future. Argentina's pork production costs appear to be much higher than in the US and Canada, due mainly to an unusually high cost of capital. Two-thirds of its cost disadvantage is due to higher interest rates alone. If they are able to reduce inflation and interest rates, Argentine costs could be much more competitive. Brazil was not included in the cost analysis but has many similarities to Argentina. Brazil has nearly doubled its pork production since 1980, according to USDA estimates cited by Drabenstott.

(Brewer and others 1998) compares pork production costs in five U.S. states (Iowa, Illinois, Nebraska, Kansas, and Missouri, but not Minnesota) with two Canadian provinces (Alberta and Ontario), the Netherlands and Denmark (Table 9). They based their comparison more heavily on averages from farm business record programs and less on budgets than did (Martin and others 1998), but arrived at the same ranking of the U.S. versus international competitors: Alberta's costs are a little less than in the U.S., while Ontario's are a little more. The Netherlands and Denmark have costs almost twice as high as in the U.S. In a companion paper, Hayenga discusses the structures of the swine industries in each of the countries compared (Hayenga 1998). He concludes that North America has a competitive advantage in export of pork products to many parts of the world where relative transportation costs are not prohibitive.

Table 9. Comparison of Pork Production Costs (U.S. $/cwt)

Item	Average U.S. MW	Large U.S. MW	Alberta	Ontario	Netherlands	Denmark
Variable cost:						
Feed cost	25.47	22.75	20.12	27.03	34.00	34.77
Labor cost	4.42	3.45	4.40	3.98	10.63	10.40
Interest	1.54	1.39	0.92	1.14	2.88	3.58
Other variable costs	5.63	5.94	5.41	6.21	14.47	11.81
Sub-total	37.06	33.53	30.85	38.36	61.98	60.56
Fixed cost:						
Housing costs	6.22	5.50	8.12	8.61	12.60	17.03
Total costs	43.28	39.03	38.97	46.97	74.58	77.59

Source: (Brewer and others 1998)

Benchmarking is a method for identifying and measuring important performance measures and best management practices for performance improvement. Benchmarking is being used extensively in many industries and service sectors from autos to education for quality and performance improvement. Management not only compares their performance with previous time periods but also with other similar actors in the business or service sector. Quality management research provides evidence that benchmarking is an effective approach to continuos improvement. Comparison of performance overtime provides measures of improvement. Comparison with the best performing businesses helps to identify competitive opportunities for improvement. A successful benchmarking program requires collective agreement on the performance measure to be used, and a system for collection and distribution of the benchmarking information. There are many references in the business literature by various

authors about benchmarking in various business and service sectors, such as (Keehley and McBride 1997) and (Bogan and English 1994).

The swine industry is evolving so rapidly that it is difficult for producers and others to determine benchmarks that can indicate what is required to remain competitive in the future. The one-time, in-depth studies can be helpful in this regard, and the Minnesota farm business management record summaries discussed later in the "economies of size" section are other sources of benchmarking data. Another source which may become available in the future is a national database which the National Pork Producers Council is developing (Anonymous 1999). This database, as proposed, will be made up of standardized production and financial information submitted by producers and summarized using standardized formulas.

Dairy Competitiveness

An Ohio Extension publication identified ten areas of dairy farm competitiveness and the role of each in contributing to the success of the business. They point out that dairy producers that want to stay competitive must commit to continued improvement, modernization and change. They suggest a better than average dairy farm today must increase the number of dairy cows by 60 over in the next 10 years to maintain their standard of living to offset inflation (Polson and others 1997).

They identified the measures listed below as guidelines for competitive performance levels.

1. Rate of production measured by pounds of milk sold per worker (For large breeds, >600,000 to 1,000,000 pounds)
2. Cost control as measured by
   - Total feed cost per 100 pounds of milk sold (<$6.00)
   - Milking herd feed cost per 100 pounds of milk sold (<$4.00)
   - Operating expense ratio (<70%)
3. Capital Efficiency as measured by
   - Dairy investment per cow (<$6,000)
   - Asset turn over Rate (>.50)
4. Profitability as measured by
   - Net farm income (>$75,000 per owner operator)
   - Rate of return on assets (>11.0%)
5. Liquidity as measured by current ratio (>1.3)
6. Debt repayment schedule measured by scheduled annual debt payment as a percent of gross receipts (<20%)
7. Solvency as measure by
   - Debt to asset ratio (<40%)
   - debt per cow (<$2,000 if not expanding, $,3,000 if expanding)
8. Mission Statement on which the management team agrees to why they are in business (Written statement)
9. Maintain family's standard of living as measured over time (Expand herd 60% every 10 years)
10. Motivated labor force (well trained, enthusiastic, empowered family and employees who share commitment to the mission and goals of the business)

Dairy farm management records suggest that many Midwest dairy businesses are highly profitable when compared to their competitors in the West, East, South, and elsewhere in the world. However, many others have the opportunity to be more competitive by: 1. increasing cow and herd productivity, 2. increasing the efficient use of capital, 3. tightening their control of costs, and 4. marketing more milk per worker. Family economics and lifestyle needs and hopes are critical on-farm forces of change. Dairy profit margins have become slimmer while family living costs have risen. Opportunities for quality family time and for breaks in day-to-day routines to get away are growing more important to many families. Success must ultimately be measured by the personal fulfillment and satisfaction of those having a vested interest in the business; it will not survive long term without being profitable. (Conlin 1998)

The Minnesota Dairy Industry's Competitive Strengths

Historically Minnesota's dairy industry has flourished because of:

- Inexpensive high quality feeds
- Plentiful supply of water
- Land with limited alternative uses (forage production)
- Desirable climate
- Committed farm families
- Positive market reputation
- Strong support infrastructure, processors, and service and supply providers

There is wide diversity in the economic vitality of Minnesota dairy farm businesses as shown by comparisons of high and low profit dairies in the state. (See Section E. of GEIS Report, Profitability and Vitality). Studies have shown that the high profit group are highly competitive nationally in being low cost producers of milk.

Wisconsin researchers identified several factors contributing to the shift from the Upper Midwest and Northeast to the West and Southwest. (Lawless 1996)

- A large number of small farms that are unable to support an adequate level of family income
- Many dairy facilities and equipment are obsolete.
- Many operators are approaching retirement.
- Changes in government milk pricing policies.
  - ⇒ Lower support prices beginning in 1981 based on anticipated purchase of surpluses and government costs that included an assessment to farmers to offset the cost.
  - ⇒ Federal Milk Marketing system that favored other regions at the expense of the upper Midwest.
- The Upper Midwest is no longer the lowest milk production cost region in the U.S..
- Many do not have access to capital needed to expand and or change their systems to be more cost efficient.

The USDA-ERS reports estimated production cost and returns for milk production by region of the U.S. The most recent estimates for 1996 and 1997 (Table 10) are consistent with a time trend

that shows the Pacific region to be the low cost-of-production region. The Upper Midwest region, which includes Minnesota, estimated Total Economic cost of producing milk at one dollar per cwt. of milk above the national average in 1997. From comparison of the cost profiles, the major difference in Upper Midwest cost of production estimates are higher variable costs, higher capital costs, higher taxes and insurance, and higher unpaid labor costs. These estimates are limited in that they reflect averages for what they consider a single typical dairy for broad regions based on assumed average input costs and returns for the region. These estimates do not capture the diversity in performance efficiencies within the region particularly in the more traditional dairy areas that are in a period of rapid change. The most sustainable dairies in the long run will be among the lowest cost producers.

Another source of data on national and international competitiveness that might be useful for future in-depth research is the Farm Level Income and Policy Simulation Model (FLIPSIM) modeling activity at the Agricultural and Food Policy Center at Texas A&M University (Anonymous 99f). That group of researchers maintains contact with a panel of representative farms across the U.S. They contact the farm operators periodically, and collect financial data which is used to develop a set of 80 farm budgets each of which represents a size and type of farm in 27 states. These budgets are used in a computer simulation model to analyze policy alternatives and make economic projections. The number of farms is too limited to permit state-level analysis, however. For example, they have no panel farms in Minnesota. Dairy is fairly well represented with farm budgets for the north central states of WI, MI and MO, northeastern states of NY and VT, western states CA, ID and WA, and southern states of NM, TX, GA and FL. The only hog farm budgets are for IL, IN, MO, and NC. Beef is represented by budgets for MT, WY, and CO. They have a number of publications listed on the web site which contain the results of analyses done using the model. One publication that contains a description of the panel farms is Policy Working Paper 98-1, REPRESENTATIVE FARMS ECONOMIC OUTLOOK FOR THE JANUARY 1998 FAPRI/AFPC BASELINE. They have also started to develop some representative farm budgets for a few other countries as well. Dairy farm budgets have been completed for Mexico and Kenya, and work has started on dairy budgets for Canada and Germany. They have not done any budgets for other types of livestock operations outside the U.S.

Table 10. Milk production economic costs and returns, per cwt, 1996-97

Item	United States		Northeast		Southeast		Upper Midwest		Corn Belt		Southern Plains		Pacific	
	1996	1997	1996	1997	1996	1997	1996	1997	1996	1997	1996	1997	1996	1997
	Dollars per cwt													
Gross value of production:														
Milk	14.78	13.43	15.19	13.74	17.41	15.87	14.74	13.32	14.88	13.46	15.1	13.7	13.89	12.77
Cattle	0.78	0.85	0.69	0.75	0.86	0.95	0.89	0.97	0.97	1.06	0.79	0.85	0.57	0.63
Other income 1/	0.61	0.59	0.51	0.46	0.5	0.52	0.77	0.75	0.52	0.5	0.4	0.38	0.57	0.56
Total, gross value of production	16.17	14.87	16.39	14.95	18.77	17.34	16.4	15.04	16.37	15.02	16.29	14.93	15.03	13.96
Economic (full ownership) costs:														
Variable cash expenses	11.49	12.19	12.51	13.32	13.27	13.25	11.19	12.15	12.47	13.02	12.27	11.7	10.08	10.71
General farm overhead	0.53	0.60	0.53	0.60	0.63	0.72	0.65	0.73	0.56	0.64	0.45	0.51	0.34	0.38
Taxes and insurance	0.33	0.32	0.44	0.43	0.37	0.35	0.43	0.42	0.31	0.29	0.16	0.16	0.13	0.13
Capital replacement	2.01	2.14	2.02	2.14	2.54	2.59	2.34	2.50	2.07	2.23	2.10	2.13	1.40	1.48
Operating capital	0.10	0.11	0.11	0.12	0.12	0.12	0.10	0.11	0.11	0.12	0.10	0.10	0.08	0.09
Other nonland capital	0.87	0.98	0.83	0.94	1.55	1.68	0.99	1.12	0.85	0.98	0.87	0.94	0.61	0.69
Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01
Unpaid labor	1.80	1.73	2.56	2.44	0.32	0.31	2.15	2.04	3.00	2.84	0.90	0.88	0.45	0.44
Total, economic costs	17.13	18.07	19.00	19.99	18.80	19.02	17.85	19.07	19.38	20.13	16.85	16.42	13.10	13.93
Residual returns to management and risk	-0.96	-3.20	-2.61	-5.04	-0.03	-1.68	-1.45	-4.03	-3.01	-5.11	-0.56	-1.49	1.93	0.03

1/ Includes the dairy's share of receipts from cooperative patronage dividends, assessment refunds, renting or leasing of dairy animals, the estimated value of manure as a fertilizer, and insurance

Source: (Anonymous 1998b)

Question D1. What choices of business organization are available to livestock producers in Minnesota and in other states? To what degree are livestock producers allowed to operate agricultural systems interdependently as opposed to independently in Minnesota and in other states and what is the significance?

D1a. What choices of business organization are available to livestock producers in Minnesota and in other states?

(Boehlje and Lins 1998) describes the basic business organization choices, which are summarized in Table 11. Choices of legal organization include sole proprietorship; partnership (general, limited, and in Minnesota limited liability); corporation (regular and subchapter S); limited liability company (not allowed in Minnesota); land trust; and cooperative. It is worth noting that, increasingly, farms may utilize more than one type of legal organization. For example, the farmland is owned by individual family members as sole proprietors, some of whom also own livestock buildings as general partners, and are also shareholders in an operating corporation which owns the livestock and equipment. There are also different business arrangements such as production contracts, joint ventures, and strategic alliances, as well as leasing options and sources of equity and debt capital.

Summaries of the status of forms of business organization utilized in Minnesota are provided in (Lazarus 99) and (Prim undated)

Most Minnesota livestock operations are organized as single-family, sole proprietorships where the farmer and/or the farm family that owns the production or owns, or leases, the productive assets provide day-to-day labor and management.

Single-family sole proprietorships, while they are common and have a rich heritage, are not the only way to organize the capital, land, labor, and management decision making required for agricultural production. There are other options, as well. The range of options for organizing and financing a business has expanded considerably in recent years due in part to innovations in financial markets. Some livestock producers are utilizing these various options in order to finance the capital needs of larger facilities while sharing control, returns and risks among multiple owners, employees, and other stakeholders.

The choices and options include legal organization, business arrangement, leasing options, and sources of both equity and debt capital. Legal organization options in addition to sole proprietorships are partnerships (general and limited), regular and Subchapter S corporations, limited liability companies, land trusts and cooperatives. The limited liability partnership is a relatively new legal option available to Minnesota farmers. Business arrangement options in addition to the traditional independent production include production and marketing contracts, joint ventures, and strategic alliances (Boehlje and Lins 1998).

Table 11. The Organizational/ Financial Structure of the Agribusiness Firm: The Choices and Options

Legal Organization	Business Arrangement	Leasing Options	Equity	Debt
Sole Proprietorship	Independent Producer	Real Estate Lease	Sources	Loans
Partnership	Contract Producer	- Cash lease	- Initial capital contributions	- Maturity
- General	Subcontractor	- Share lease	- Retained earnings	- Interest rate
- Limited	Joint Venture	- Flexible cash lease	- Stock	- Amortization arrangement
Corporation	Strategic Alliance	- Shared appreciation lease	* Common stock	- Prepayment features
- Regular	Franchise Agreement	Facility/ Equipment Operating Lease	* Preferred stock	- Security/ collateral
- Subchapter S	Licensing	Capital/ Financial Lease	- "External" equity	- Conversion of terms
Limited Liability Company		Leveraged Lease	- Warrants or options	- Shared appreciation mortgages
Land Trust		Leasebacks	- Venture capital	- Reverse mortgages
Cooperative			Business Practices	- Interest rate strips, futures, options, swaps
			- Payout (dividend or withdrawal) policy	Bonds
			- Intrafamily transfers	- Convertible bonds
			- ESOPs and stock options	- Callable bonds
			- "Buyout" policies	- "Zero coupon" or deep discount bonds

SOURCE: NCR-568, *Planning the Financial/Organizational Structure of Farm and Agribusiness Firms: What Are the Options?*, August 1998.

Legal organization choices are regulated in Minnesota and many other states (Hoppe 1996). In Minnesota, Statute 500.24 places limitations in the amount of farmland which a corporation can own. Corporations are prohibited from engaging in agriculture, except for family farm corporations and authorized farm corporations. Certain other exceptions to the prohibition also apply. Limited liability companies are prohibited from engaging in agriculture in Minnesota, and the regular business corporation laws apply to farming in the same way that they apply to other businesses. There are tax implications to the choice of legal organization. Harl includes a discussion of corporate farm laws in Minnesota and other state, as well as discussing the process of incorporation, what taxes apply, and other factors to consider (Harl 1996a). The text of Minnesota's corporate farm law is accessible on the World Wide Web at the address listed in the reference list.

The rationale for regulating legal organization choices in agriculture is given in subdivision 1 of 500.24: "The legislature finds that it is in the interests of the state to encourage and protect the family farm as a basic economic unit, to insure it as the most socially desirable mode of agricultural production, and to enhance and promote the stability and well-being of rural society in Minnesota and the nuclear family." For a related discussion, see the "Economic Development, Industry Competitiveness, and Fiscal Impacts" section of this web site, and in particular see the publications Lasley, et al., pages 137-39, and Lazarus listed in the list of references for that section.

Production networks are a type of business arrangement popular in the Minnesota swine industry. A recent University of Minnesota report lists things to consider when joining a network (Koehler, et al.) It includes a financial analysis of a typical arrangement, and includes a spreadsheet template for analyzing specific situations.

Boehlje and Lins (Boehlje and Lins 1998) have described a comprehensive range of options for organizing and financing farm business firms, and explain circumstances in which various options are likely to be most useful (see Table 12). These options have expanded in recent years as innovations in financial markets have created new alternatives to meet varied needs. Historically, financing focused on internally-generated equity, with debt used if internal resources of equity were not adequate to finance the growth of the business. Sole proprietorship has been the dominant organizational structure, with limited forward or backward linkage (i.e., contracts or ownership of successive stages of production). Current options are much broader in terms of 1) business and legal arrangements, 2) asset control strategies, and 3) financing instruments/options.

Boehlje and Lins point out the need for strategic planning to capture the best financial and organizational structure for the business. They outline the criteria for making these choices.

- **Control:** The fundamental objective for independent control and individual decision making may be a dominant factor in preponderance of sole proprietorships in the farm business sector.

- **Returns:** This objective focuses on which option will allow access to resources and funds at the lowest cost and emphasizes the set of economic activities that maximizes profit. The tax

treatment and resulting tax burden of alternative are important, as are the various ways of sourcing funds.

- **Risk:** This element involves four issues:

  Claim of various parties on income or revenues: Because of legal structure, contract agreement, or financial arrangements, various parties have different claims on the business. Characteristics of these claims, including amount, certainty, and priority, will determine impact on risk.

  Claim on assets: Legal and financial arrangements carry specific claims on the assets of the business. These claims are frequently conditional in nature and contingent on specific financial performance, which will determine the impact on risk.

  Bankruptcy/legal liability: The risk of financial loss from bankruptcy and legal liability depends heavily on financial and organizational structure. The use of multiple legal entities may help protect assets of entity from liability. The organization and financial structure can significantly affect potential liability exposure.

  Failure: Success or failure is influenced in part by the financial and organizational structure. Failure may result in losses in value or other consequences for related business ventures, as well as self-esteem and respectability of the owners.

- **Maturity/Permanence/Liquidity:** The longevity or permanence of the arrangement is reason for choosing an option. Some business arrangements are difficult or costly to dissolve once they are set up while others are more flexible and have a shorter-term maturity.

LEGAL ORGANIZATIONS

Part of the strategic plan for organizing and financing a business is how to combine the legal/business arrangements to satisfy the specific goals. More than one legal arrangement is frequently used in successful business ventures.

Harl compares various forms of farm business organizations and state restrictions on corporations in the North Central Region (Harl 1996a). There are three basic forms of business organizations: sole proprietorship, partnerships, and corporations. Variations of these are limited partnerships, and the tax option corporation. These forms are described as follows:

Sole Proprietorship is when one person operation owns, runs and manages the business. There may be many hired employees.

Partnership is an aggregation of co-owners to carry on the business for profit. Two or more persons contribute assets and share management and responsibility for profits and losses. Each partner is liable for the actions of all partners within the scope of partnership activities.

Limited partnership is a special form of partnership where liability for debts and obligations is limited to the investment of the limited partners. Limited partners are just investors. A limited

partnership must have a general partner who handles management of the business and is fully liable for all partnership debts and obligations.

Corporation is a separate business entity distinct from its owners. The corporation draws a sharp line of distinction between the business and the owners, the shareholders. The corporation is a separate legal person as well as a separate taxpayer. The limited liability feature of a corporation is important. Shareholder risk is usually limited to the amount of their investment. An employee, officer, or director may be personally liable for negligent actions even though the corporation is also liable. Corporation assets are not liable for personal obligations. The life of the corporation does not depend on the life of the people, and the continuity of the business is not affected by the death of a shareholder or the transfer of stock. Therefore the corporation offers a method of maintaining the farm business as a going concern, avoids the interruptions that result upon death, and provides for managers to do the long-range planning necessary to keep pace with technical advances. Minority shareholders may be disadvantaged by being locked into the rule of the majority and have no power to compel directors to pay dividends on the stock. A corporation may be dissolved by a majority vote, or the state can revoke a charter if the corporation fails to comply with state laws. Lenders may have less fear that death or incapacitation of a single individual might cause termination of the business. Lenders are likely to be more liberal in extending credit if there is evidence of management succession and business continuity. Ownership is easily divided into shares of stock. New investment may be made by the purchase of stock or by lending money to the corporation. Shareholders receive a share of the profits after the salaries have been paid. Lenders incur less risk by receiving a fixed rate of interest. There are limitations on loans from federal and federally related agencies. Shareholders can be employed and be eligible for employee benefits such as retirement plans and tax-free medical benefits. Employee benefit plans can not discriminate in favor of shareholder-employees and against others. Shares of stock provide a simple and convenient way to transfer property. Shares of stock may be sold, given away, or transferred by will or under state inheritance laws at death. Shares of stock provide a means for gradual transfer and progressive shift in ownership in the business. A minor may own stock.

Some characteristics of corporations are often considered to be a disadvantage: all wages and salaries are subject to FICA including children under 18 years of age; some states may require all employees to be covered by worker compensation insurance, whereas not for partners or sole proprietors; shareholders must meet at least annually for a shareholders meeting, and corporations are required to file and annual report and pay an annual fee (Harl 1996a).

Tax option corporation (sometimes called a subchapter S corporation) is a creation of the federal tax law. It is a corporation in all respects except that it generally pays no income tax because each shareholder-owner reports a share of corporate income tax.

Limited Liability Company (LLC) is a hybrid that allows the limited liability of a corporation and tax treatment of a partnership. LLCs are more informal in organization and in operation than a corporation. LLCs offer the owners limited liability like a corporation without facing the double tax on business income like a regular corporation, and does not restrict the number of owners and other limitations of an S-corporation. Under some circumstances a LLC could fail to be classified as a pass through tax status entity and become classified as a corporation. Laws

permitting LLCs vary from state to state, but most states now allow this form of legal business entity. Added information on LLCs can be found in (Minnesota State Legislature 1998).

Limited Liability Partnership is also a hybrid with general partnership features but has some aspects of limited liability associated with corporations. Liability of a partner is eliminated for negligence, wrongful acts, and misconduct of other partners and partnership employees, agents and representatives. Each partner remains personally liable for their own conduct and for those under their direct supervision. Each partner remains personally liable for any commercial obligations of the partnership such as loans, leases, taxes and wages. Creditors have recourse against partnership assets including the investments of individual partners. Many states have also enacted legislation providing authority for limited liability partnerships.

Harl has compared the characteristics of the farm business organizations (Table 12). Boehlje and Lins have summarized the general characteristics of some additional business organizations in Table 13 (Boehlje and Lins 1998).

Boehlje and Lins have described two additional legal forms of business organization that are less common but coming into greater use.

Land Trust is a legal entity that allows a land owner to transfer property to a trustee. The powers of ownership are governed by a trust agreement which places the possession and management powers in the hands of the beneficiaries. The primary benefits are the avoidance of probate upon death, insulation of land from legal judgments, avoidance of problems of multiple ownership, and privacy of ownership. The main problems are management, limited duration (typically 20 years), termination of trust, and loss of homestead exemption. Additional information on land trusts can be found in (Harl 1996a).

Cooperatives: Increasingly farmers are using the cooperative structure to jointly acquire and provide machinery and equipment services, breeding stock, marketing and selling services, advisory and consulting services, and other assets and services. A cooperative is an incorporated business capitalized by its member patron/owners and remits margin to its patron/owners in proportion to their patronage business. A cooperative is taxed on income at corporate rates but patronage refunds are tax deductible to the cooperative if specific rules are met (Harl 1996b). Wisconsin workers describe New Generation Cooperative (NGC) that differ from most traditional marketing cooperatives in that it is market driven, closed with limited members, tradable membership shares, allocate rights to deliver units of the farms raw products, but shares spread up-front capitalization responsibility equitably among its members. Wisconsin workers report that the number of new generation cooperatives in the upper Midwest expanded from two in 1989 to over fifty in 1996. They point out these cooperatives involve cooperation among farm families, provide a means of benefiting from economies of scale, and are usually value added enterprises adding value to grain and forage through the end livestock product. (Lawless 1996)

Table 12. Comparison of Farm Business Organizations

Issue	Sole Proprietorship	C Corporation	General/ Limited Liability Partnership	Limited Partnership	Limited Liability Company	S Corporation
Nature of Entity	Legal person same as the owner	Legal person separate from shareholder-owners	Aggregate of two or more persons	Aggregate of two or more persons	Aggregate of two or more persons	Legal person separate from shareholder-owners
Life of Business	Fixed term; ends when owner dies	Perpetual or fixed term of years	Agreed term; terminates at death of partner; LLP must register annually	Agreed term; terminates at death of partner	Agreed term; terminates at death of partner	Perpetual or fixed term of years
Management Decision	Sole proprietor	Elected directors and officers selected by directors	Usually agreement of partners	Usually general partner	Usually manager is elected	Elected directors and officers selected by directors
Formation of Entity	Very simple	Relatively simple	Relatively complex; LLP must register	Relatively complex	Relatively simple	Relatively simple
Flexibility in Capitalization	N/A	Very flexible	Very flexible	Very flexible	Very flexible	Somewhat inflexible
Limited Liability	None	Yes	No; LLP partner exempt from co-partner's torts	No for GP / Yes for LP	Yes	Yes
Flexibility in Conducting Business Affairs	Inflexible	Flexible	Flexible	Relatively flexible	Relatively flexible	Somewhat inflexible
Flexibility in Taxable Year	None	Yes	No	No	No	Little
Allocation of Income, Losses, Deductions, and Credits	N/A	Somewhat inflexible	Very flexible	Very flexible	Very flexible	Generally inflexible
Tax Effect Upon Liquidation	No double tax	Difficult to avoid double tax	No double tax	No double tax	No double tax	Generally no double tax (Section 1374)
Convertibility to Another Entity Tax-Free	Yes	Some restrictions	Yes	Yes	Yes	Some restrictions
Line of Business	Very flexible	Few restrictions	Flexible; LLP some restrictions	Very flexible	Few restrictions	Few restrictions
Self-employment Income from Entity	Yes	No	Yes	Yes - GP / No - LP	Usually; see proposed Regs § 1.1402(a)-18	To extent of salary and bonus
Effect of Passive Loss Limitation Rules	N/A	Applies at corp. level; generally avoidable for larger corps.	Partners may or may not materially participate	Ltd. partners deemed not to materially participate	Members may or may not materially participate	Shareholders may or may not materially participate
Availability of Entity Losses to Owners	N/A	No	Flow through of losses to owners	Flow through of losses to owners	Flow through of losses to owners	Flow through of losses to owners
Fringe Benefits	Limited compared to C Corporation	Widest available	Limited compared to C Corporation	Limited compared to C Corporation	Limited compared to C Corporation	Limited compared to C Corporation
Estate Planning Opportunities	Fair	Very good	Good	Very good	Very good	Fair
Accumulated Earnings and PHC Tax	N/A	Section 531 and Section 541 applicable	No	No	No	No
State Taxes	Same as individual	Generally uniform and deductible	Generally uniform	Generally uniform	States vary	States vary
Dividend Received Deduction	N/A	Allowed	Not allowed	Not allowed	Not allowed	Not allowed
Effect of Bus. Liabilities on Owner's Basis	Full effect	No effect	Proportionate share	Limited partners share in non-recourse	Proportionate share	Only shareholder's own loans
Alternative Minimum Tax	Subject to AMT	Subject to corporate AMT	Preference items flow to each partner	Preference items flow to each member	Preference items flow to each member	Preference items flow to each shareholder
Method of Accounting	Cash method	Depends on size and ownership	Generally may use cash method	Generally may use cash method	Generally may use cash method unless farming syndicate	Generally may use cash method

SOURCE: McEowen, Roger and Harl, Neil E., *Principles of Agricultural Law*, Agricultural Law Press, 1997.

Table 13. Comparison of Farm Business Organizations [§]				
	Sole Proprietor	**Partnership**	**Corporation**	**Land Trust**
Nature of Entity	Single individual	Aggregate of two or more individuals	Legal person separate from shareholders	Separate from beneficiaries and trustees
Life of Business	Terminates on death	Agreed term; terminates at death of partner	Perpetual or fixed term of years	Fixed term of years with extensions thereafter
Liability	Personally liable	Each partner liable for all partnership obligations	Shareholders not liable for corporate obligations	Beneficial interests subject to attachment, not land
Source of Capital	Personal investment; loans	Partners' contributions; loans	Contributions of shareholders for stock; sale of stock; bonds and other loans	Settler
Management Decisions	Proprietor	Agreement of partners	Shareholders elect directors who manage business along with officers elected by directors	Beneficiaries and trustee by trust and management agreements
Limits on Business Activity	Proprietor's discretion	Partnership agreement	Articles of incorporation (by-laws) and state corporation laws	Trust and management agreements
Transfer of Interest	Terminates proprietorship	Dissolves partnership; new partnership may be formed if all agree	Transfer of stock does not affect continuity of business. Stock may be transferred to outsiders if there are no restrictions.	Assignment of beneficial agreements
Effect of Death	Liquidation	Liquidation or sale to surviving partners	No effect on corporation. Stock passes by will or inheritance.	Trust agreement and trust code interests are personal property by will or laws of decent
Income Taxes	Income taxed to individual	Partnership files an information return but pays no tax. Each partner reports share of income or loss, capital gains and losses as an individual.	*Regular Corporation:* Corporation files a tax return and pays tax on income; salaries to shareholder-employees are deductible. Capital gains are offset by capital losses. Rates, July 1, 1987: 1st $50,000, 15%; next $25,000, 25%; over $75,000, 34%.[‡] *Tax-Option Corporation:* Corporation files an information return but pays no tax. Each shareholder reports share of income, operating loss, and long-term capital gain.	Income, depreciation, and expenses pass to beneficiaries in proportion to the beneficial interest held

[§] Table taken in part from NCR-11, *The Farm Corporation.* Land trust added by G. Harrison.

[‡] An additional 5% tax (maximum amount of $11,250) is imposed on a corporation's taxable income above $100,000. This provision phases out the benefit of the 15% and 25% rates for corporations with taxable incomes of more than $335,000.

SOURCE: NCR-568, *Planning the Financial/Organizational Structure of Farm and Agribusiness Firms: What Are the Options?*, August 1998.

BUSINESS ARRANGEMENTS

Farmers have a wide choice of business arrangements they can use in addition to the legal form of the business. The alternatives include: independent production, contract production, subcontractor, joint ventures, strategic alliances, franchise agreements, and licensing.

Independent producer is the most common method of conducting business. The firm is free to buy inputs from whomever and where ever it pleases and whatever market channels it chooses. The independence of the operator's decisions is the key advantage of this business arrangement. In some commodities, however, economic forces are making it less feasible for independent producers to compete effectively in an increasing integrated market.

Contract Production is increasing in popularity in livestock and crop production. Contracts have become commonplace in the production of various vegetable and specialty crops, broilers, turkeys, and increasingly in hog and milk. The contract agreement is between the producer and an input supplier or processor. Contract agreements are highly variable in scope but likely to take on one of the following forms:

Product specification contracts include detailed product specifications relative to quality characteristics and sizable discounts occur if quality standards are not met.

Resource Providing specify the contractor will supply specific services.

Price-or risk sharing contracts specify a guaranteed price for products with specific quality attributes, specify a minimum profit margin above a calculated cost of production, and sharing the margin above a calculated cost or some combination.

Market Access guarantees access by the producer to the processing facility. It is usually a flow scheduling device to use processing facilities more efficiently

Subcontracting or Contract for Services: These arrangements can take many different forms but essentially involve the payment for services provided. It usually involves fewer services or functions than contract production. It may involve payments for feed processing, labor services, custom feeding of hogs or cattle, custom harvesting, manure spreading, or chemical application. Producers may participate on either side of these contracts.

Joint Ventures: A separate business entity or subsidiary is formed by two or more firms to jointly carry out specific business activity. It may be done in an informal fashion to jointly own machinery or equipment, feed or breed livestock, market products or buy inputs. Agribusiness firms have used joint venture arrangements for purchasing, distribution, or merchandising activities often as part of a large scale national or international market.

Strategic Alliance : Strategic alliances may be formal or informal to work jointly to achieve a desired end result, goals or procedures. They can work in many different ways, be quite flexible, and are often of limited duration. Each firm has a vested interest in the success of the other firm

but do not share ownership of assets. An example would be a packer forming an alliance with a group of producers and a feed company to be assured an even flow of quality pork.

Franchise Agreements: These arrangements are most common in the food distribution chain. The benefits come from name recognition, efficiency of promotion, and standardization of product and service functions.

Licensing: This arrangement is not common in production agriculture but is more common in the input supply and/or product processing industries. It is a way a firm that possesses a certain technology but lacks the resources to exploit it completely can license it to another firm for a fee. For example biotechnologies that require large investments to develop, may be licensed to other firms to more fully exploit its use.

Leasing: Leasing allows one to acquire control of an asset for a fee without the requirement of ownership. Some view leasing as an alternative form of financing. And is a common method of financing an asset used in agriculture. It is more frequently used for real estate and buildings that for machinery and equipment. There are various forms of leases.

Cash lease typically involves a cash payment for the annual right to farm or graze a parcel of real estate. Payments are a function of productivity, local supply/demand, but typically fixed with full or partial payment in advance. About 64 percent of farmland leases were cash leases in 1992.

Share Lease: Both tenant and landlord share some part of the expenses and income. Common share leases in the US are 50-50 share with tenant and landlord sharing equally. A share lease may involve livestock production and is typically more complex than crop share leases. About 30 percent of farmland leases in 1992 were share leases.

Flexible cash lease: Annual lease payment may be dependent on yields or price. These arrangements are usually combine with a fixed base to guarantee a minimum lease payment. This has the feature to transfer some of the risk from the tenant to the landlord.

Shared Appreciation Lease: This is a farmland lease that allows tenant to pay a higher than normal rent in exchange for some share of future capital gains. This allows the tenant to improve the property and share in the value of the increase, and provides for acquiring an equity interest in property without borrowing money. This method has been suggested for institutional owners of farmland but is largely untested in practice. More information on this arrangement can be found (Lins 1990)

Facility/Equipment Operating Lease: Operating leases are typically seasonal or annual with renewals in length, with no ownership rights or responsibilities to the lessor. They usually involve a piece of equipment, warehouse space, etc. for a period of time.

Capital/Financial Leases: These leases are longer term, usually a function of the life of the asset to allow the lessee to recover the purchase price of the asset. They are treated much like debt-financed asset purchase from an accounting perspective, and are included on the balance sheet. Qualified capital leases receive unique tax treatment, fully deductible, which may be a major

advantage. They are more popular in agribusiness than at the farm level, and are used for major equipment items. In many cases, the option to buy at the end of the lease is structured to encourage purchase or replacement with another leased asset.

Leverage Lease: These leases involve three parties, a lessor, a lessee, and a lender. The lender makes a loan to the lessor that enables him/her to purchase the asset. The lessor then leases the asset to the lessee. These are common in the transportation industry and could be used more in agriculture. These arrangements allow advantageous use of the tax and financial position of the lessor and lessee.

Leasebacks: This arrangement is commonly used to restructure financially-stressed businesses. The business sells the asset to another with a lease back provision. This provides the lessee use of the property. These leases can be effective to improve asset liquidity, and operating flexibility of the business.

EQUITY AND DEBT CAPITAL

An owned business has two fundamental sources of funds, debt and equity. There are a number of alternative forms of debt and equity to make apparent simple decisions complex. (Boehlje and Lins 1998) have described various forms of equity and debt capital. These forms are listed below:

Equity Capital
- Initial Capital contributions
- Retained Earnings
- Stock
- External Equity
- Warrants or Options
- Venture Capital

Debt Capital
- Loans
  - Interest Rates
  - Amortization arrangements
  - Prepayment Features
  - Security/collateral
  - Conversion terms
  - Shared appreciation mortgage
  - Reverse Mortgage
  - Index rate strips, future, and options
- Bonds
  - Convertible Bonds
  - Callable Bonds
  - Zero Coupon or deep discount bonds

D1b. To what degree are livestock producers allowed to operate agricultural systems interdependently as opposed to independently in Minnesota and in other states and what is the significance?

General Comments

It is beyond the scope of this project to do the legal research needed to describe the corporate farming laws and other laws related to business arrangements in every state in enough detail to assure complete accuracy and currency. It is apparent these laws are in a state of continuing change. (Dahl 1991) provided a fairly comprehensive review in 1991 in which he identified nine states of the fifty states (North Dakota, South Dakota, Minnesota, Wisconsin, Iowa, Illinois, Kansas, Missouri, and Oklahoma), as having major restrictions on corporate farms. He refers to a U.S. Supreme Court case which concluded that state corporate farming restrictions do not violate the U.S. Constitution or the fourteenth amendment because property law is chiefly a state matter. He includes a map of the US showing states with major or minor restrictions on farm corporations. One significant change since Dahl wrote his report is that Illinois no longer has major restrictions on corporate farms. That state repealed its Agricultural Land Ownership Act in 1996. Also, Nebraska is listed by Dahl as having only minor restrictions, although that state is often viewed as having one of the tightest restrictions in the nation (see reviewer comment). Another source of information on corporate farm laws in every state as of December 1992 is (Aiken 1993).

Neil Hamilton and Greg Andrews of Drake University Law School provided a review of state regulation of contract feeding and packer integration in the swine industry in 1992 (Hamilton and Andrews 1992). They identified nine Midwestern states that have enacted corporate farming laws. These were the same states identified by Dahl except that Illinois was not on his list, and Nebraska was. Hamilton and Andrews conclude that the language of each law differs but that many arguably prohibit contract production of livestock either directly or indirectly. They indicate that contract feeding and packer integration were controversial and coming under scrutiny in several states. Their conclusions were that:

1. It is within the states' power to either place restrictions, prohibit or establish guidelines for how contracting may be done,

2. Minnesota's legislation is the most ambitious example of state regulation of contract feeding,

3. If a state is determined to regulate contract feeding, then efforts should be made to deal with the identified problems associated with it and the likely concerns if its use should spread,

4. Legislation concerning contract feeding does not necessarily have to prohibit or restrict its use but rather can establish guidelines to protect financial interests of producers and insure fairness of contracting methods,

5. One claimed risk of contract feeding legislation is that it will drive contract production to other states,

6. Anti-corporate farming laws can be interpreted as prohibiting both contract feeding and packer integration by restricted business entities,

7. If contract production increases, states may need to consider legislation to protect producer rights to organize and bargain for fair marketing practices.

Neil Harl provided a review of business structure alternatives to assist farmers in determining their best options in 1995. This publication focused on twelve North Central states and provides a review of state laws in these states at that time. Harl discusses the advantages and disadvantages of various forms of business structures, how they operate, what taxes apply, and the process of incorporation and dissolving the business (Harl 1996a).

Mark Edelman at Iowa State is leading a project of the National Extension Public Policy Committee, which compared regulations by state. A preliminary report is available at (Edelman 1999). Edelman's results were based on voluntary survey responses from Extension Public Policy faculty in each state. Of the 35 states responding only five states indicated their state government prohibited corporations or other entities from owning farmland or engaging in confined livestock operations. These states included Iowa, Kansas, Minnesota, Nebraska, and South Dakota.

Minnesota's Corporate Farm Law was first enacted in 1973. A brief history of Minnesota's law is available in (Dahl 1991). Producers are allowed wider latitude to operate interdependently in other livestock activities in Minnesota, compared to dairy, where only family farm corporations, and authorized farm corporations with five or fewer shareholders are allowed. Minnesota does not allow the legal form known as a limited liability company (or LLC) to be utilized in agriculture. LLCs are allowed in most other states. A summary of Minnesota's restrictions on forms of legal organization allowed in agriculture are shown in Table 14.

Mark Hanson points out that that livestock operations are expanding in the Midwest to take advantage of competitively priced feeds and scale efficiencies possible in larger more modern operations (Hanson). As the size of this venture increase, substantial capital must be employed to construct, develop, and implement viable production and marketing entities. These significant capital requirements demand participation by investors, both on farm and off farm, which prudently will require corporate liability protection. The business structure allowed in a given state becomes a central issue to livestock venture formation. Corporate farming laws tend to severely restrict the type of business entity and venture that may be entered into. Security laws in some states have a significant impact on raising equity for a project.

Comments on Individual States' Restrictions

Minnesota: The Minnesota statute 500.24 Corporate and Partnership Farming can be accessed at http://www.revisor.leg.state.MN.us/stats/5000/24.html.

Minnesota generally only allows family farm, family farm corporations, authorized farm corporations, authorized livestock farm corporations (except for dairy cattle), family farm partnerships, and authorized farm partnerships to engage in farming or acquire any interest in agricultural land. "Family" requires that a majority of the shareholders be related to each other

within the third degree of kindred and a least one of the related persons is residing on or actively operating the farm. (Hanson)

Minnesota repealed a 5,000 limitation on land that could be owned by a farm corporation in 1973. They enacted a detailed statute requiring farm corporations to file an annual report, and limited expansion of corporate farming operations except for family corporations and authorized farm corporations.(Harl 1996b)

The law was amended in 1975 to further restrict who can operate an authorized corporation: shareholders cannot exceed 5 and are natural persons or an estate; the corporation has only one class of stock; revenues from rents, royalties, dividends, interest, and annuities cannot exceed 20 percent of gross receipts; shareholders holding 51 percent or more of the stock must reside on the farm and be actively engaged in farming; the corporation cannot own more than 1,500 acres of land used for farming; and a shareholder of an authorized corporation cannot be shareholder in another corporation that owns more than 1,500 acres of farmland. (Harl 1996b; Hanson)

In 1994, the limits were relaxed for corporations formed for production of livestock other than dairy cattle by natural persons or family farm corporations that provide 75 percent or more of the capital investment; 75 percent or more of the control and financial investment must be held by farmers residing in Minnesota; and at least 51 percent of the required farmers must be actively engaged in livestock production. Previous other limitations to authorize corporations apply to the new category of livestock production corporations. Dairy cattle production continues to be an exception to the other types of livestock production and is restricted from an authorized corporation as a legal form of business in Minnesota.(Harl 1996b) . A Limited Liability Company is not a legal business option for agricultural producers in Minnesota.

Hanson (Hanson) identifies an exception to corporations or limited liability companies for a breeding stock farm that owns land for the purpose of raising breeding stock including embryos for resale to farmers. A breeding stock farm that is organized to raise livestock other than dairy cattle must sell castrated animals to be fed out or finished to farming operations that are neither directly nor indirectly owned by the entity operating the breeding stock operation.

Neither general partnerships nor limited liability partnerships are covered by the corporate farming restriction, but partners must be exempt themselves from the corporate farm laws for these entities to be used. (Hanson)

Hanson summarizes by concluding that Minnesota restrictions make structuring animal agriculture other than poultry with liability protection difficult. Authorize livestock corporations may be used other than dairy but they restrict investments from non-exempt entities. For dairy, generally only a limited liability partnership may be used. He suggests the possibility of joint ventures in which the buildings and animals are owned by a non-exempt entity and exempt entities conduct the farming and production activities.

Table 14. Summary of Legal Agricultural Business Organizations in Minnesota

ENTITY TYPE	ELIGIBLE SHAREHOLDERS	INELIGIBLE SHAREHOLDERS	NUMBER OF SHAREHOLDERS	LIMITED LIABILITY	PASS-THROUGH TAXATION	DAIRY AND ROW CROP ELIGIBLE
General Partnerships	Natural persons, partnerships, other entities certified under the corporate farm law	Entities that are not certifiable under the corporate farm law, i.e. partnership of non-qualifying corporations	Unlimited	No; joint and several liability exits for each partner	Yes	Yes
Limited Partnerships						
A. Family Farm Limited Partnerships	Natural persons, partnerships, limited partnerships, limited liability partnerships	Corporations, limited liability companies	Unlimited, but the majority of the shareholders must be related within the 3rd degree of kindred	Yes, for limited partners. However, there must be at least one general partner that retains liability.	Yes	Yes
B. Authorized Farm Limited Partnerships	Natural persons	All non-natural persons such as partnerships and corporations	Up to 5; no relation required	Yes, for limited partners. However, there must be at least one general partner that retains liability.	Yes	Yes
Corporations						
A. Family Farm Corporations	Natural persons, partnerships, limited partnerships, limited liability partnerships	Corporations, limited liability companies	Unlimited, but the majority of the shareholders must be related within the 3rd degree of kindred	Yes	Depends on whether the corporation is a Subchapter C or Subchapter S	Yes
B. Authorized Farm Corporations	Natural persons	All non-natural persons such as partnerships and corporations	Up to 5; no relation required	Yes	Depends on whether the corporation is a Subchapter C or Subchapter S	Yes
C. Authorized Livestock Farm Corporation	Natural persons and family farm corporations	All non-natural persons other than family farm corporations	Unlimited, but 75% must be farmers, and 51% of the 75% must be livestock farmers	Yes	Depends on whether the corporation is a Subchapter C or Subchapter S	No; only eligible for corporations engaged in livestock production other than dairy cattle
Limited Liability Partnerships	Natural persons, partnerships, other entities certified under the corporate farm law	Entities that are not certifiable under the corporate farm law, i.e. partnership of non-qualifying corporations	Unlimited	Yes; the partners may elect to have some of the partners have less than joint and several liability	Yes	Yes
Cooperatives	Treated the same as corporations					
Business Trusts	Treated the same as corporations					
Limited Liability Companies	Prohibited; no exceptions					

Source (Prim undated) MN Department of Agriculture

A brief description will be provided for other neighboring Midwestern states taken from Hanson (Hanson) and Harl (Harl 1996b), except for the South Dakota information which is taken from South Dakota Statute 47-9A (South Dakota Legislative Research Council 99).

Wisconsin: Wisconsin will permit corporations to own land and carry on farming providing there are no more than 15 shareholders, no more than two classes of stock, and all shareholders are natural persons. However Wisconsin law prohibits corporations from engaging in the production of dairy, and hogs. Wisconsin also has a breeding stock exemption. Wisconsin corporate farm law does not prohibit poultry and egg production.

Iowa: Corporate ownership of agricultural land is prohibited. Processor ownership of beef and pork feedlots is restricted. If an entity other than a sole proprietorship or general partnership desires to own land in Iowa, it must fit into one of the following forms of ownership: a chapter 501 cooperative, a family farm corporation, an authorized farm corporation, a family farm limited liability company, a networking farmers corporation, a networking limited liability company, a farmers cooperative association, or a farmers cooperative limited liability company. The ownership structure depends on the makeup of the entity owners.

To qualify as a family farm entity, a family farm corporation or family farm limited liability company, the majority of members or stockholders must be related to each other as spouse, parent, grandparent, or lineal descendants of their grandparents or their spouses. All stockholders or members of an authorized farm corporation or limited liability company must be natural persons and number no more than 25.

The networking farmer entities - networking farmers corporation or networking limited liability company - may hold interest in up to 640 acres of agricultural land if at least 75% of the entity's gross receipts are from the sale of livestock or livestock products. Natural persons actively engaged in farming, or a general partnership in which all partners are natural persons engaged in farming must own 51% of the issued shares and qualified persons must own at least 70% of all issued shares. A qualified farmer is a natural person actively engaged in farming, a general partnership in which all partners are natural persons actively engaged in farming, or a farm estate. Qualified persons are qualified farmers, a family farm entity, or a qualified commodity share landlord. Networking entities can be formed with non farm entities so long as the percentage ownership requisite is met.

Authorized Farmer Cooperative, (FCA) farmer cooperative associations and (FCLLC) farmers cooperative limited liability companies, may hold interest in up to 640 acres of agricultural land if it does not produce forage or grain. They may enter agreement with a person to produce forage or grain so long as the grain is not received as payment for the lease. Qualified farmers must own at least 51% of the equity interest and qualified persons must own 70% of the equity.

FCLLC cooperatives must own 100% of all membership interests, and FCA's must own 70% of the interests. These business forms also permit joint ventures with non-farm cooperatives so long as the 70% ownership requisite is met by FCAs.

Chapter 501 Cooperative may acquire, lease, or otherwise obtain up to 640 acres of agricultural land if authorized farming entities own 60% of the stock and are eligible to cast 60% of the votes

at member meeting. An authorized farming entity is a natural person who regularly participates in the physical labor on the farm or one of the permitted corporate forms of ownership. Natural persons or partnerships must own at least 75% of the stock and be eligible to cast 75% of the voted are member meetings.

Processing entities that control the manufacturing, processing, and preparation for sale of beef or pork products are restricted from owning, controlling, or operating hog or cattle feedlot if their annual wholesale sales is greater than 10 million dollars. They may participate in the breeding and farrowing of swine but cannot directly or indirectly control the finishing portion of the operation or provide feed and care for the animals for more than ten days. They can contract for purchase of swine and cattle for slaughter.(Hanson) .

North Dakota; North Dakota generally allows only limited liability companies or corporations with less than sixteen members or shareholders related to each other to own real estate or engage in the business of farming. Officers or members must be actively engaged in farming and at least one must live on the farm. Excepted from this restriction are cooperative corporations where seventy-five percent of its members or shareholders are actual farmers residing on farms or depending principally on farming for their livelihood.

South Dakota: The family farm act of 1998 provides restrictions on corporations or limited liability companies from forming or being licensed for the purpose of owning, leasing, holding, or otherwise controlling agricultural land to be used in the business of agriculture, including facilities for the breeding, farrowing, and raising of swine. Family farm corporations with at least one shareholder residing on the farm or actively farming, and authorized small farm corporations with 10 or fewer shareholders, are exempt. There are other restrictions to this rule. For example, facilities for the purpose of feeding poultry for meat and egg production, and facilities for feeding livestock are exempt.

Nebraska: The Nebraska constitution allows only family partnership, family farm corporation, and family ranch corporations to acquire any interest in real estate used for farming and engaged in farming or ranching. Related individuals must hold a majority of the stock and at least one of them must reside or be actively engaged in the day to day labor and management of the farming operation. This prohibition includes non-stock cooperatives. There are exceptions to this corporate farming restriction; for example, agricultural land used for poultry production is excepted.

Kansas: Statewide, Kansas restricts agricultural land ownership to authorized farm corporations, family farm corporations, limited liability agricultural companies, family farm limited liability agricultural companies, and limited agricultural partnerships. There are some qualifying limitations and exceptions. Agricultural land may be held or leased by a corporation or limited liability company for use as a feedlot, poultry confinement facility, or rabbit confinement facility. There are some special county approval restrictions on corporate or limited liability company use of agricultural land for swine or dairy production.

Illinois: The Agricultural Land Ownership Act was repealed effective August 14, 1996. The Illinois statutes, administrative rules, and case law neither restrict nor expressly permit corporate ownership for profit of an agricultural pursuit.

Summary Comments

There is wide diversity in the limitations placed on business structure and arrangements among the fifty states. Most states do not prohibit corporations or other entities from owning farmland or engaging in confined livestock operations. Midwestern states tend to be more restrictive in the business structures allowed for agricultural use (Edelman 1999), (Dahl 1991). From the above review of Midwest State limitations, there is inconsistency in the language of the laws and how the laws apply to types of livestock production, poultry, swine, dairy, or beef. The rationales for these differences are unclear. It is evident that many states have provisions for exceptions, and that interpretation of laws in place has changed over time. There is wide diversity in the environment regulations among states(Edelman 1999). Hanson points out that environmental and zoning laws strongly impact location decisions (Hanson 1998).

There is very little documentation on who owns and controls livestock or other farm assets in Minnesota, as discussed below in section D5 on ownership and control. Anecdotal information suggests that there are farm families who working together in multi-family operations using the various legal forms and business arrangements mentioned above to achieve desired control, return and risk objectives. To the extent that the previous statement is true, multi-family operations are a research topic that relates to question D1b on interdependent vs. independent operation. One study on multi-family operations is (Lawless 1996). This Wisconsin study points out that the single greatest factor affecting multi-family operations are outside economic and demographic forces to which families can only react. Their discussion focused on dairy farms but the principles apply to other livestock classes. They discuss five rationales motivating farm multi-family businesses:

Farm viability: This rationale assumes the best way to survive is to expand their operation. Some families do not have the capital and cannot acquire the financing to do it alone so are attempting to do it with others. Some see the advantage of scale efficiencies and combining capital, labor, and management expertise as a means of improving efficiency, and reducing unit production costs.

Quality of Life: By involving more families in larger operations, the workload and management can be parceled so that no one individual is overly burdened. Some do not want to commit to the 365 day responsibilities of operating a single family operation and their descendant are less likely to want to make this commitment.

Value added: Some farm families are looking to add value to their farms grain and forage production through a mutual investment in a commonly owned livestock enterprise and enjoy the gain of addition value added income.

Return on Investment: This rationale is to achieve a fair return on their capital investment in the business.

Community Economic Development: Non-farm community interests in generating jobs, markets, and economic vitality in the community.

Question E3. How do government policies, regulations and programs affect the profitability and viability of livestock farms and firms in Minnesota? How do governmental policies in other states and countries differ from those in Minnesota with respect to their impacts on farm/firm profitability and viability in those places, and what can we learn from their experiences?

Impact of State and Local Policies on Locational Shifts of the Swine Industry

The significance of the state corporate farm laws and state and local environmental policies is difficult to evaluate reliably. One approach, which provides a general indication, is to compare the trend in market share over time in states with more and less restrictive policies. This was done in a recent Pennsylvania State University study of the swine industry in 13 major producing states over the period 1988-95 (Mo and Abdalla 1998a) (Mo and Abdalla 1998b). This was a linear regression analysis with the dependent variable being the annual percentage change in hog inventory by year, for the states IL, IN, IA, KS, KY, MI, MN, NE, NC, OH, PA, SD, and WI. Sixteen independent variables were included covering four categories: Natural Endowment, Economic Factors, Business Climate, and Regulation Factors.

Of the four categories, economic factors were found to have the greatest influence on swine industry growth: the hog-corn ratio, percentage of farms with a hog inventory over 1,000 animals, and state slaughter capacity having positive impacts on growth. It is interesting that growth was more rapid in states with higher land values rather than lower ones, as might have been expected.

They included seven variables to measure the restrictiveness of state and local policies:

- Green index of general environmental regulations at the state level
- Lester classification of states' commitment to environmental protection activities and institutional capabilities
- Stringency of states' animal waste programs, based on rankings by three experts
- Staffing levels devoted to state animal waste control programs
- Average amount of fines imposed annually by state regulators
- Presence or absence of an anti-corporate farming law in the state
- Presence of absence of an agricultural exemption to local zoning

The impacts of the policy variables were as follows: The Green and Lester measures were found to have mixed influences on growth. The Lester measure placed more weight on enforcement capability, and was associated with lower growth (Mo-Abdalla do not provide details on the variables entering into the Lester and Green measures, but they cite other publications which describe them in detail). The measure of stringency of animal waste programs was insignificant, possibly because of the way it was measured. Fines tended to have a negative impact on growth. Higher staffing levels were also expected to suppress growth but had the opposite effect, possibly because the causality runs the other direction -- the industry grows, and then staff is increased in response. Growth was more rapid in states with agricultural exemptions to local zoning. Anti-corporate farming laws, on the other hand, did not slow growth. It should be noted that they did not attempt to measure how strict each state's anti-corporate farming law was.

The business organization form known as a Limited Liability Company or LLC, which is not allowed for agriculture in Minnesota, is another alternative to an authorized farm corporation as a way for farmers to operate interdependently. The administrative costs of setting up and operating an LLC are said to be less than for a corporation, so documenting those differences could be one aspect of this research.

(Drabenstott 1998) argues that environmental regulations have recently been and will in the future be a major influence in the future location of the pork industry. This is a summary of statistical data from a variety of sources with interpretive comments about driving forces and possible future directions. As we discuss in the introduction, his expert opinions and predictions about future directions like any predictions are not verifiable with empirical research data but are included here to stimulate discussion.

He does not quantify the impact of the regulations on profitability of existing farms. We have often heard it asserted in producer meetings that tighter regulations requiring such changes as installation of improved manure storage structures would lead to many livestock producers with older facilities and limited incomes to quit rather than make the change. The example often used is a farmstead built around a hundred years ago next to a body of water for easy access to drinking water, which now would have to be completely rebuilt at a different location further away. We are not aware of published research that describes Minnesota's livestock businesses in terms of how many have such problems and how costly the problems would be to fix. Our understanding is that the feedlot inventory that has been proposed as part of the GEIS might provide the data for such an economic analysis.

Even if tighter regulations do not require existing livestock facilities to be modified, competitive pressures due to productivity improvements elsewhere in the industry may reduce the profitability of existing facilities. Producers will then be forced to expand, renovate or replace them (refer to the treadmill hypothesis mentioned under question E2a), at which point they become subject to increased regulatory scrutiny. See discussion of Outlaw et al. below for empirical results related to this point.

Drabenstott argues that the new pork supply chains with tens or hundreds of thousands of sows prefer large-scale units, and so have tended to locate their units in non-traditional pork producing states such as Utah and Oklahoma because of their less restrictive environmental regulations. The states are responding rapidly with tighter regulations, however. He was not able to locate a definitive listing of state environmental regulations affecting the pork industry (check Mo and Abdalla, and Copeland and Hipp references). He states,

> "What is clear is that firms in the pork industry are comparing regulatory climates across state lines and even county borders in search of places with fewer regulations. Analysts are divided on how important environmental regulations are in causing geographic shifts in production." (p. 91)

He also states that there is no comparison available on state-by-state variation in the overall costs of compliance with environmental regulation. It seems clear that if precise quantitative estimates of compliance costs are desired for the GEIS, new research will be needed to derive them.

Drabenstott claims that two environmental issues will be important in shaping pork industry location decisions:

- whether a national set of environmental standards is enacted, and
- differences in regulation across national borders.

The EPA has announced that it wants final action on national guidelines by December 2001. Drabenstott argues that standardized national standards would tend to push location decisions to the local level, where some communities are eager to embrace the industry while many others are not. He also argues that standardized national environmental regulations would highlight the role of corporate farming laws, which are addressed under question D1b.

We could find few published empirical analyses of the cost of livestock operations' compliance with environmental regulations. One reason for the dearth of work on this area may be that the regulations are evolving so rapidly and vary so much across localities and farm types. It is difficult to arrive at a small number of representative farm situations that can be analyzed to provide results that are generalizable to the range of farm situations that are out there, and that will stay relevant into the future.

Cost of Compliance with Dairy Waste Management Regulations

One empirical analysis of dairy farms' cost of compliance with 1993 U.S. Environmental Protection Agency standards is (Outlaw and others 1993). They did an analysis of budgets for a number of representative farms using their Farm Level Income and Policy Simulation Model (FLIPSIM). They looked at several dairy farm sizes in different regions of the U.S. They used the EPA Region VI standards as the basis for comparison, and adjusted them for climatic and soil conditions in the other states. The did not study Minnesota, but for Wisconsin they found that minimum capital investments for compliance ranged from $20,000 on a 50 cow farm to $40,000 on a 175 cow farm. Also:

"Moderate size dairies were found to be affected more adversely by being required to meet the specified Region VI EPA regulations than large size dairies. Dairies that were already in financial trouble could be put out of business by requirements to conform with the Region VI EPA standards. Many of these dairies, however, could go out of business regardless of the EPA requirements, albeit at a later date.

Large scale dairies that were not already in financial trouble appear to be able to amortize the extra capital investment costs associated with meeting the Region VI EPA requirements. This suggests that moderate size dairies faced with needing to make investments to meet the EPA standards may choose to expand the scope of their operations, if financially able. While such expansion would require an even larger investment, it also would hold the potential for making the dairy more efficient and competitive." (p. ii)

International Policy Developments

Federal and international agricultural policy is a very broad topic with a voluminous literature. The question was raised in a meeting of the GEIS Citizens' Advisory Committee as to the extent

to which this response should address national-level policies in the U.S. and other countries, and how they might enter into the eventual GEIS policy recommendations. The sense of the group seemed to be that the response should focus on describing recent national-level policy developments and economic trends which might most directly affect the outcomes of Minnesota's policy alternatives.

The USDA Economic Research Service has published an extensive series of reports on international agriculture. A list of the specific publications with abstracts, and full text of most reports, is available on the Internet at (USDA Economic Research Service 1999). One of the reports listed there, Agricultural Competitiveness: The Case of the United States and Major EU Countries, finds that U.S. agriculture has remained competitive largely due to its comparative agricultural productivity as measured by total factor productivity (TFP). Since TFP growth in U.S. agriculture is strongly associated with public R&D and infrastructure, the relative competitiveness of U.S. agriculture, in the long run, is likely to depend on its ability to sustain and increase growth in TFP. Another report, Transition Economies: International Agriculture and Trade Situation and Outlook Report, discusses how the livestock industry in central and eastern Europe and the former USSR has been hurt by the economic reform there. A third report, Agriculture and European Union Enlargement, uses a computer model to analyze the 1992 Common Agricultural Policy reform and discusses possible effects of EU enlargement. Potential accession of a number of eastern and central European countries into the European Union (EU) seems destined to lead to further reforms of the Common Agricultural Policy (CAP). The financial costs of absorbing these countries may be extreme. There are a number of other reports on other issues.

One issue that has the potential to affect agricultural exports is the rising number of regional trade agreements such as the North American Free Trade Association (NAFTA) and the Southern Common Market MERCOSUR). A recent study concluded that the European Union, which is the only region for which a fully implemented trade agreement has been in effect for decades, has seen an overall decline in both intra-E.U. and extra-E.U. agricultural exports since the E.U. was formed. Thus, E.U. agricultural policies appear to have diverted trade to member countries. European Union policies have not created agricultural trade opportunities for the rest of the world. The overall conclusion of the study is that RTAs appear to have contributed positively to the specialization and division of labor in agriculture among already trading nations, permitting more common and open trade policies.

Question D3. How are livestock businesses different from and similar to non-agricultural businesses with respect to the following factors, and what are the implications of these differences:

There are a tremendous number of ways in which livestock businesses and non-ag businesses are different and similar. This question as stated is much too broad to be researchable. Environmental Quality Board staff indicated that this question grew out of concerns such as: "Does agriculture receive special treatment in terms of public policy and public sentiment, and should it receive such special treatment?" and urged us to address the question from that perspective. From a practical standpoint, one way to narrow this question to a manageable scope would be to state a few specific policy issues which call for such a comparison. If that were done, we would be better able to start to focus on the similarities and differences that are most

likely to be important to addressing those policy issues. For example, one policy issue might be: "Should the state give livestock facilities and other agricultural property preferential property tax rates compared to other businesses and residential property?" One way in which studies have addressed this question is to compare costs of public services to tax revenues. One such study is (Senf 1994), which found that farmland in Farmington, Lake Elmo, and Independence required less than $1 of expenditures per $1 of revenues, and a lower ratio of expenditures than did residential or commercial/industrial land. At least two studies of the cost of urban sprawl are currently underway, one by the Twin Cities Metropolitan Council and another by the Minnesota Department of Agriculture (Taff). Additional studies are cited in a paper by the Lincoln Institute of Land Policy (see Taff for source). They caution that:

> "Fiscal impact studies must be carefully evaluated, since the choices of methodology and assumptions greatly influence the findings. It has been noted, for example, that 'the results of most fiscal impact analyses conform with the policy inclinations of the governments or organizations that sponsored them.' (Altshuler et al. 1993, page 92). Burchell and Listokin (1992) also note that few fiscal impact analyses are tested for reliability by comparing actual costs and revenues after development with pre-development projections. Finally, since specific circumstances vary considerably from community to community, generalizations should be made with caution."

Comments on the individual factors:

a. location

One approach to this would be to compare how dependent different county or metropolitan economies are on agriculture, versus other industries. A map of farming-dependent counties is available on the USDA web site, along with similar maps showing dependence on other industries (Anonymous 99c). The criterion for the farming dependence map is that at least 20 percent of labor and proprietors' income is from farming. Roughly half of the counties in southwestern and west-central Minnesota, along with most of the Red River Valley region and a few counties in the southeastern part of the state, are dependent on agriculture by this measure. Minnesota appears to be less dependent on agriculture than the region further west, including most of the Dakotas, Nebraska, western Kansas and eastern Colorado, and down into northern Texas.

A larger question might be how diversified county economies are, versus how dependent on any one industry, whether agriculture, mining, forestry, steel, or whatever. On the other hand, if the policy question of the moment is whether to enact some policy which affects the economic viability of agriculture, then knowing how dependent one's economy is on agriculture would help one predict the impact of the policy.

Various web sites are available which allow searching for government economic statistics such as jobs, income, and number of firms by industry and by state, county, or municipality. One is the U of MN Humphrey Institute of Public Affairs' Economic Development web site (Anonymous 99b). We could compile some summary information from these databases, but most of that work might be better left until some specific policy questions are identified.

A recent analysis of U.S. Bureau of Labor Statistics payroll data shows that most rural Minnesota counties are gaining manufacturing jobs, although the author cautions against complacency about the future. Most gained manufacturing payroll between 1988 and 1996 by more than the national average increase of 28.3 percent (Beal 1999). By this measure, at least, the economy of the state's rural counties may depend less on the livestock industry than it once did. The complete study is available in (Zimmerman 1998). A comparison of Minnesota counties bordering other states against counties in the other states bordering Minnesota shows that the other states are doing better (see Zimmerman's Table III-4, not duplicated here). Jobs in the other state counties increased by 32 percent from 1988 to 1995, while the Minnesota border counties increased by 20 percent. Furthermore, most of Minnesota's border growth came in one county, Dakota. Minnesota border counties other than Dakota only increased by an average of 8 percent. The recent decision by Anderson Windows to locate a new factory in Menomonie, Wisconsin rather than in Woodbury, Minnesota reinforces this concern (Hughlett 1999).

Another recent USDA study found that manufacturers in rural and metropolitan locations are remarkably similar in their adoption of new technologies, worker skill requirements, use of government programs and technical assistance, exports, and sources of financing, based on a national survey (Gale and others 1999). The most widespread concern was with quality of labor.

Study question 3 asks how livestock businesses are different or similar to non-agricultural businesses. Most industry comparison statistics lump all farms into one industry category, so it is easier to compare all agriculture with non-ag than to compare just livestock businesses. Employment, for example, is not split out separately for livestock versus crop enterprises. Most farm operators raise both livestock and crops, and the share of time spent on livestock varies widely. One can estimate the share of employment involved in producing a particular species of livestock by such means as multiplying typical labor requirements per animal times animal inventories, but such estimates would not be very accurate.

b. technology employed

At a very aggregate level, "technology" implies a mix of capital, labor, and land which differ across different types of businesses. We were unable to locate any publications that compare technology in livestock businesses with non-agricultural businesses, other than personal computer use. In 1995, 15 percent of U.S. farms (including both livestock and crop farms) reported using computers for bookkeeping and financial analysis, 6 percent for production decisions, 2 percent to aid chemical application or field operations, and 0.8 percent reported use of global positioning systems (Sommer and others 1998). In a June 1997 nationwide survey, 43 percent of Minnesota farms reported having access to computers, 32 percent owned or leased a computer, 22 percent used computers in the farm business, and 11 percent had Internet access (Anonymous 1997e). The Minnesota numbers were not split out for livestock operations versus crop, but the data for the north central region was split out. North central livestock operations' computer usage was very similar to that for all Minnesota farms. Minnesota farms' usage was a little higher than that of all U.S. farms except for the category of Internet use, where 13 percent of all U.S. farms reported having Internet access compared to 11 percent of Minnesota farms.

Computer use by workers in non-metropolitan areas is at 36 percent and increasing rapidly, but still lags behind use by metro workers whose rate is 49 percent based on data from the Current

Population Surveys for 1984, 1989 and 1993 (Kusmin 1997). The differences are attributed to differences in the mix of occupations. (Gale 1997b) discusses a wider range of manufacturing technologies and differing rates of use by manufacturing plants in metro and non-metro locations, but does not include farms.

c. business concentration

This topic has been widely studied for at least some industries. In agriculture, most work has focused on the meatpacking industry. Most work that has analyzed business concentration has done so from the standpoint of how concentration might affect business conduct and performance (such as ability to charge monopoly prices). The production agriculture sector, including livestock businesses, has been regarded as not concentrated enough to raise performance concerns, so to our knowledge has not been studied much.

d. use of land as a resource

We have been able to locate few studies that directly compare use of land as a resource by livestock businesses and non-agricultural businesses. There are databases that describe land use by agriculture. For example, the U.S. Census of Agriculture contains data on land in farms and in various crops on a nationwide basis and by state and county (Anonymous 1998c). The Minnesota farm business summaries contain data on crop acres owned and rented by farms with different types of livestock (Olson and others 1999), (Anonymous undated). We are aware of databases of land use data that are focused mainly on conservation issues, and databases exist that contain land use statistics for non-agricultural industry categories such as timber by type of ownership (Anonymous 1998a). We have not delved very far into this topic due to uncertainty about what the real questions are and the criteria for comparison that are of interest. Further focusing of the question is needed to improve researchability.

One possible way to narrow this question to a more manageable scope would be to consider only those aspects of land use that affect the amount of water pollution originating from land used by livestock businesses and other businesses. One study in that vein is a 1991 survey of Twin Cities residents on the use of lawn care chemicals, including fertilizers and pesticides (Creason and Runge 1992). They found that average levels of fertilizer application appeared to fall below recommended levels, and that pesticide application rates were similar to non-urban agricultural use. They stressed the need for follow-up studies to obtain better information.

e. patterns of ownership and control

(Strasser 1989) is one source that discusses ownership and control in retailing, which has parallels with what is happening in the livestock industry. For example, during the 1880's and 1890's, local retailers protested the rise of department stores and mail-order houses (page 215). Legislation passed in 1912 that authorized parcel post shipments was controversial, since it benefited Sears and Montgomery Wards and was a severe blow to retail merchants (page 81). Of course, the current controversies over WalMart taking business away from rural main street retailers illustrates that the retail industry continues to evolve. Further comments are included under question D5a below.

f. government regulation and assistance

Government is involved in all sectors of the economy in a myriad of ways. It would be easier to compare livestock businesses with the rest of the economy if some sort of index such as dollar cost could be assigned to each government program and totaled up for each industry. To arrive at such an index would necessitate comparing against a hypothetical case of no government involvement, however. As (Browne and others 1992) point out,

> "A market system totally free from government involvement is a misnomer. Market systems require ownership of resources and the right to collect returns from those resources. So government has to be involved from the outset to establish some public agreement on protecting the ownership rights of individual entrepreneurs. The way these rights are established has definite repercussions for market performance (in other words, for the allocation of resources to their most valuable and best use) and for the distribution of wealth in a society." p. 129

Lacking a way to sum up the overall effect of all types of government involvement, we can still identify publications which merely describe the major types of regulation and assistance. One recent summary of federal programs affecting rural businesses in general is (Bowers 1998). They list targeted tax cuts, disaster aid, transportation programs, housing assistance, welfare-to-work programs, and regulatory changes including telecommunications, electric power, air and water pollution, public land management, banking, and finance. Many of the federal programs affecting agriculture are included in farm bills, which in recent years have been passed roughly every five years. Most provisions of the Federal Agriculture Improvement and Reform Act of 1996 are well known, but for a summary see (Young and Westcott 1996).

g. public perceptions

Is this question intended to evaluate the often-heard perception that agriculture is viewed more favorably by the public than are other industries, and deserves special treatment in government policies? There are several rationales for this perception, such as: 1) a moral or Jeffersonian argument that farmers are more deserving than other people just because they work the land and produce a product, food, which is more essential than many other products; 2) a regional economics-based argument that at least some rural communities have few other industries to depend on for tax revenues and trade; and 3) a social argument that owner-operators are more likely to be stable and involved in the local community than are people who work for others, and that owner-operators make up a larger share of the agriculturally-based population than for other industries.

Farmers' values were compared to those of the general population with respect to morality, political ideology, work ethic, and outlook, in (Drury and Tweeten 1997). Using data from the General Social Surveys of the National Opinion Research Center at the University of Chicago, they found that:

> "Compared with the general population, the farm family is more stable, the typical farmer is more religious, politically more conservative, and happier and more satisfied with some aspects of life. "In many aspects, particularly those

> concerning work ethic and outlook, farmers are not different from others. Nonetheless, as a group, farmers are among the better-adjusted members of society. They are optimistic and have a healthy outlook on life in terms of interpersonal relationships and general viewpoint." (p. 68)

They conclude that farmers' unique attributes can translate into positive externality benefits which the public can weigh against the costs of government interventions to save family farms. Offutt, et al. took Drury and Tweeten to task, arguing that the basic question of preference in policy for farmers is a matter of equity -- of societal and political preference for redistribution among favored and less favored groups -- not one of (economic) efficiency. They also questioned the definition of morality used (Offutt and others 1998), (Drury and Tweeten 1998).

A earlier nationwide mail survey by Tweeten found that the public was much concerned about farm problems and committed to preserve the family farm. The public was generally supportive of government efforts to help farmers but tended to be undecided regarding specific measures (Jordan and Tweeten 1987).

There are perhaps over one hundred publications that relate to public perceptions of a wide range of specific issues more or less related to agriculture. They do not appear to be relevant to the ag versus non-ag comparison question posed here, so will not be cited individually, but some of the issues addressed in different studies are:

- biotechnology (the most widely researched issue, by far)
- food hazards
- transmissible spongiform encephalopathies (mad-cow disease)
- food irradiation
- agrichemicals or pesticides
- feed additives such as growth promotants and antibiotics
- how farmers treat the soil
- agricultural research
- regulatory changes
- natural resources management or wilderness management
- river management and storm water management
- fish farming in general, and shrimp farming in particular
- fee hunting
- the pulp and paper industry

A 1995 BRE (Business Retention and Enhancement Program) in Becker and Ottertail counties surveyed dairy producers on their perception of how they thought dairy farmers were perceived in the community. The responses for negative or indifferent attitudes toward dairy farmers were: Farmers (not dairy producers) 42%, Main Street Businesses 47%, Local Government Officials 51%, Rural non-farm residents 64%, and City residents 73%. Of the 131 respondents 73% indicated that it was highly likely they would continue to produce milk through the next three years, with larger herds indicating they planned to continue dairying. (Morse 1995) A similar study in Stearns county in 1997 ranked the top five characteristics dairy farmers valued about dairy farm life: 1) Good place to raise a family 2. Opportunity to make own decisions 3. Time to

be used with family 4. Economic rewards from farming and 5. Opportunity to work outdoors. Of the ninety two percent of the respondents in this survey that plan to continue farming over the next three years, 41% said they were likely or very likely to expand their dairy operation. (Love 1997)

The Iowa Farm and Rural Life Poll is conducted annually by Iowa State University to address major farm and rural issues (Lasley and Larson 1998). The 1998 report presents farmers' opinions about economic development directions that have been pursued or suggested for Iowa. Improving rural infrastructure, maintaining a world class educational system, and diversifying agriculture were supported more strongly in 1998 than ten years earlier. There was also strong support for local processing, placing more emphasis on agricultural exports, and funding biotechnology research, but support for these was down slightly from 1988. A majority thought their quality of life had improved in the past five years. They were mainly optimistic about continued improvement in their own family's quality of life, but less optimistic about their communities. There was an increase in concerns about odor and noise from livestock operations.

Question D4. What is the current market situation, how is the market changing and what are the implications for livestock producers with respect to the following factors:

a. consumer demand (including brand loyalty)

We found a large body of literature related to Question D4 on the changing market situation. We have cited some refereed journal articles on consumer demand, but we concluded that many of the changes in food distribution and retailing that may potentially affect producers are better described in various USDA reports and trade magazines. The USDA Economic Research Service monitors trends in food consumption. The latest numbers by commodity, and a discussion of the methodology used to measure consumption, are presented in (Putnam and Allshouse 1999). Food consumption is generally measured indirectly, by subtracting non-food use from supply numbers.

When economists refer to consumer demand, they are generally referring to a concept that is somewhat broader than simply per capita consumption at a point in time:

> "Demand is a schedule of different quantities of a commodity that buyers will purchase at different prices at a given time and place." (Kohls 1967), p. 131.

Two consumer demand research issues that have received considerable attention by academic researchers over the past decade or so are:

- How has the relationship between quantity demanded, on one hand, and price, socioeconomic and other observable variables changed over time, and
- What is the impact of advertising, especially generic versus brand advertising?

The first question is especially important for price forecasting. For example, researchers have studied how consumers' preferences have evolved as a result of a growing awareness of the health hazard of high fat intake. (Moschini and Meilke 1992), (Green and Alston 1990), (Eales and Unnevehr 1988), (Eales and Unnevehr 1993), and (Eales and Unnevehr 1994) are all studies

that looked at structural change in U.S. meat demand and approaches to estimating demand elasticities.

Interest in the second question has been motivated at least in part by the desire to evaluate the effectiveness of producer check-off-funded generic advertising for milk, meat, and eggs. (Brester and Schroeder 1995) studied the effects of meat advertising expenditures on beef, pork, and poultry demand. Studies of milk advertising include (Lenz and others 1998), (Kaiser and Liu 1998), (Pritchett and others 1998), (Kaiser and others 1992), (Suzuki and Kaiser 1997). (Schmit and others 1997) looked at the impact of generic advertising on egg demand.

Generic advertising has raised fluid milk sales an estimated 18.1 billion pounds (6.0%) and cheese sales by 6.8 billion pounds in the period September 1984 and September 1997. The impact on sales of butter and frozen products was unaffected. These researchers estimated milk prices were 2.3 percent higher than they would have been in the absence of the program. They estimated the gross return for each dollar of the 15 cents per hundredweight assessment to return $3.44 from the generic advertising. (Blisard 1999)

In 1993, a random sample of 515 consumers in the metropolitan Minneapolis-St. Paul, Minnesota area were surveyed to learn more about consumer preferences for meat characteristics (Kinsey and others 1993). Some key findings were that only four percent of households had increased beef consumption over the past year while 37 percent had decreased beef consumption. Seven percent of the households did not eat meat at all. Concerns about diet and health cut across age and educational groups, and these concerns were correlated with a decrease in beef consumption. There were a number of other findings having to do with eggs, poultry, fish, income levels, and fat substitutes. They identified nine market niches such as "low fat," "safety," and "price conscious" households. Over half were willing to pay more for beef that is free of antibiotics and growth hormones, but less than one-fourth were concerned about humane treatment of animals for meat and only 16 percent worried about their environmental impact. Many did not know what to think about these issues.

Trend data on where food is purchased might be important to producers who are considering direct marketing or other alternatives to the mainstream food distribution system. Tables 103 and 104 in (Putnam and Allshouse 1999), not duplicated here, provide data on where food is purchased in the U.S. For example, the percentage purchased directly from farmers, manufacturers and wholesalers has been flat in the 1990s at around two percent. A more in-depth analysis of direct marketing as a rural development tool is provided by (Gale 1997a). Gale cites growing interest in direct marketing by both consumers and producers, but also cautions that direct selling is still relatively small and limited to communities close to urban areas. His analysis is based on data from the 1992 Census of Agriculture. The 1997 Census of Agriculture has become available since that article was published, and might provide more recent data on direct marketing income potential (Anonymous 1998c).

Producers who plan to continue to market through mainstream channels may be interested in the rapid change taking place in the food distribution and retailing sector. The changes appear to be driven partly by consumer demographics and partly by opportunities presented by new information systems. Numerous changes have been occurring in the food wholesaling, food store retailing, and foodservice industries that compose the consumer food distribution channels

(Connor and others 1997). Increasing levels of concentration in wholesaling and at the food store level, and a shift away from merchant wholesalers toward more direct negotiation between food store chains and manufacturers are some of the trends cited. One new initiative that promises to lower costs and improve efficiency is Efficient Consumer Response, which is a cooperative effort between processors, wholesalers, and retailers to improve distribution efficiency and customer service. Connor et al. also speculate about whether the so-called "British Model" of grocery retailing might catch on in the U.S. That model entails fewer retail chains - five retail chains account for more than 80 percent of the UK market. They would carry fewer manufacturers' brands and more private-label brands, with retail employees playing a greater role in new product development. The UK retailers earn two to four times the profit rate of their American cousins. The UK model may be starting to influence U.S. retailers, as evidenced by Sainsbury's recent acquisition of two large retail grocery chains in the northeastern U.S. They appear to be making over these acquisitions in the Sainsbury image.

Producers and others can also get a general sense of retailers' perspectives on what is changing and why by reading trade magazine articles such as (Tosh 1999). For example, according to Tosh one challenge that full-line meat distributors such as Supervalu face is the large number of individual items which distribution centers must handle. In its larger divisions such as the northern region, the number of items can reach 1,700. The variety of retailers supplied by the wholesaler is part of the problem, such as the Byerly's stores in Minneapolis handle exclusively prime beef while many other stores do not stock the product. Improved packaging is allowing retailers to increase volumes of case-ready products. Category management is a management technique that Supervalu and others are adopting to improve profitability, in marketing areas where sales and demographic data are available. Another article in the same magazine describes how the distributor and retailer attempt to determine the optimal mix of national brands and private brands for the store.

What are the implications of these food distribution changes for producers? Tosh provides a general understanding of the changing marketplace. It does not include the level of detail that would be required to quantitatively analyze specific farm-level production and marketing alternatives. Cash register scanner data, for example, might be useful for some types of analysis but is not generally available to academic researchers. It is our impression that some farm operators with sufficient resources and entrepreneurial savvy are establishing relationships with processors and distribution firms which give them access to such information. The potential for such coordination may be a significant incentive for farmers to increase their operation size or to work together with other farms.

Demand for food in the aggregate is not very responsive to price changes because there is little opportunity to substitute non-food items in the consumers budget (Putman 1997). However demand for individual foods is responsive to prices as consumers demand more convenience and quality. Rising income increases expenditures for more expensive food items. Consumer purchases represent a vote in the market place that provides feedback through the system about their preferences. Changes in the makeup of the population, lifestyles, incomes, attitudes on food safety and health, and convenience have drastically affected conditions for producers and marketers of food products.

There have been some major shifts in the eating habits between 1970 and 1996 (Anonymous 1998e):

Coffee	-35%
Eggs	-28%
Beverage Milk	-22%
Red Meat	-15%
Alcoholic Beverages	17%
Fats and Oils	21%
Fruits and vegetables	23%
Caloric sweeteners	24%
Fish	26%
Flour/Cereal Products	46%
Poultry	90%
All Carbonated soft drinks	114%
Cheese	143%

U.S. food and beverage expenditures as a share of total personal consumption expenditures have fallen from 32.1 percent in 1947 to 16 percent in 1996. The 1996 number includes 9.6 percent for consumption at home and 5.4 percent consumed away from home (Connor and others 1997). They also discuss the implications of changing consumer preferences on growth potential for different types of food products. For example, they use supermarket sales data to document rapid growth in:

- highly convenient foods,
- Asian, Hispanic and Mediterranean foods,
- low-calorie foods,
- packaging that preserves freshness,
- snacks, and
- perceived healthy or natural foods.

USDA researchers studied the potential adjustment in agricultural production as the U.S. diet moves toward the dietary recommendations specified in the Food Guide Pyramid. Their results shown in table 15 project an increase in animal products of milk, yogurt, and cheese, and of meat, poultry, fish, dry beans, eggs, and nuts. The major reductions are projected in sugars, fats and oils, and starchy vegetables. (Young 1998)

Farm retail spreads have increased every year for the past 30 years. The average payment for farm raw products in 1997 was 23 percent of retail cost. The farm- retail spread varies greatly by product Agricultural fact Book 1998

b. concentration of buyers

Concentration in the Meatpacking Industry

Changes in concentration in U.S. commercial livestock slaughter between 1909 and 1994 are summarized in (Azzam and Anderson 1996), pages 22-30. The percentage of slaughter done by the top four firms has been rising since the mid-1980s, and was at 82 percent for steers and heifers, 73 percent for sheep, and 46 percent for hogs in 1994.

Table 15. 1995 food supply servings compared with Food Guide Pyramid recommendations.

Food group	Food Guide Pyramid recommendation for a 2,200-calorie diet[1]	1995 food supply servings	Change needed to meet Pyramid recommendation
	Servings	Servings	Percent
Grains	9.0	9.4	--
Vegetables	4.0	3.7	8
Dark green leafy and deep yellow vegetables	1.3	0.3	333
Dry beans, peas, and lentils[2]	0.6	0.2	200
White potatoes and other starchy vegetables	0.8	1.3	-38
Other vegetables	1.3	1.9	-32
Fruit	3.0	1.3	131
Citrus, melons, berries	1.5	.6	150
Other fruit	1.5	.7	114
Milk, yogurt, and cheese[3]	2.2	1.8	22
	Ounces	Ounces	
Meat, poultry, fish, dry beans, eggs, and nuts[4]	6.0	5.7	5
	Grams	Grams	
Added fats and oils[5]	38	59	-36
Added sugars[6]	12	32	-63

[1] USDA, CNPP, 1996; Cronin et al., 1987.
[2] Dry beans, peas, and lentils can be counted in either the vegetable or meat groups. Counting these foods toward "vegetable group" servings is consistent with other dietary assessment studies.
[3] Recommendation based on a weighted average of recommended servings for different age groups of the U.S. population.
[4] Food supply servings reflect both the lean and fat portion of meat and poultry.
[5] The Food Guide Pyramid does not make a recommendation for added fats and oils. The upper limit reported here is based on the assumption that added fats and oils contribute the same 52 percent of total fat in the food supply as in 1994, and that total fat is no more than 73 grams of 30 percent of total calories for a 2,200-calorie diet.
[6] The recommendation for added sugars is a suggested upper limit based on caloric intake.

Source: (Young 1998)

Concentration, conduct, and performance of the meatpacking industry has been extensively studied (defining performance by measures such as the ability to charge monopoly prices). One recent study was organized by GIPSA in 1992 and published in 1996 (Anonymous 1996). One of the seven individual projects conducted as part of the study was a literature review of the economic history of the meatpacking industry, theory, and evidence (Azzam and Anderson 1996). (Azzam 1998) is an updated summary of the literature review. (Heffernan and others 1999) documents the increasing concentration of agricultural production and processing in the

hands of the top firms and the development of food chain clusters of firms combined in a variety of business relationships.

(Heffernan and others 1999) and (Azzam 1998) present differing perspectives on the issue of increasing concentration. Heffernan et al. predict that four or five global clusters of food firms will emerge. One interesting observation made in the Heffernan paper is that other concentration studies may tend to focus too much on individual firms, and so may miss important information by neglecting the relationships (e.g. joint ventures or strategic alliances) among firms within a cluster. They argue for government intervention on the grounds that the current highly concentrated structure allows a handful of firms to control the food system and capture higher-than-competitive profits at the expense of independent farmers and rural communities, and that the concentrated food system is too vulnerable to disruption. They do not attempt to measure differences in performance between more and less concentrated industry structures, but rather argue that the risk of poor performance is too great to delay action until empirical data becomes available.

Azzam reviews the studies which have attempted to measure the relationship between concentration and performance in the meatpacking industry. Some studies were done along the traditional lines of the Structure-Conduct-Performance (SCP) paradigm; others were based on more recent methods from what has become known as the New Empirical Industrial Organization (NEIO). Cross-industry studies in the 1960s focused on profitability as the measure of performance. They found that industry profitability increased with concentration, and these studies had an effect on antitrust policy of that era. These studies were criticized, however, over interpretation of profitability-concentration correlations. An alternative interpretation was that firms become large because they are efficient due to greater managerial skills and innovativeness. Later studies shifted their focus from comparing profits across industries, to comparing prices across geographically separated markets within a single industry. Using price as the performance indicator instead of profit was thought to be a better way to measure market power because price would not pick up effects of efficiency differences that would affect the profitability measure. Most SCP studies of market power in the US meatpacking industry were of the price-concentration sort. NEIO models focus more directly than SCP models on what type of industry conduct is consistent with observed prices and quantities, and can test a variety of oligopoly theories.

Azzam (Azzam 1998) views the above empirical studies as one way of assessing competition - taking a snapshot of industry equilibria at a point in time. The studies offer little understanding of how the industry reached where it was at that point or whether, in fact, the economic data used in the studies represent equilibria. Azzam concludes that the evidence from both SCP and NEIO models on balance seems to indicate a (statistically) significant but small departure from competitive conduct. The implication is that both consumer and producer welfare could be increased by steering packer behavior toward closer conformity with the perfectly competitive benchmark. The question is whether one should target the structure or conduct of the industry.

The question of whether the positive efficiency gains from industry consolidation outweigh the negative effects of greater market power remains an issue. Azzam cites two studies of beefpacking which attempted to find out whether the cost reductions achieved through economies of plant size or multiplant operation offset allocative efficiency resulting from

deteriorating packer market conduct, (Azzam and Schroeter 1995) and (Azzam 1997). Azzam and Schroeter found that the anticompetitive effects of a 50 percent increase in concentration were, at most, on the order of 2.4 percent. This was well below their estimate of actual cost savings of 4 percent which is likely to be generated by a 50 percent increase in the size of a representative plant in the industry. They concluded that the structural changes in beef packing in recent years have been welfare enhancing on balance. Azzam (1997) used a different approach but also found that the cost-efficiency effect outweighed the market-power effect.

Azzam argues that from a historical standpoint, the meatpacking industry has performed well in terms of innovation. It can be viewed as competitive in a dynamic sense of optimizing the allocation of resources between the present and the future. Profits are the returns to the innovative activity necessary to maintain a dynamically competitive process, and the appropriate type of competition to be concerned about is not static price competition, but competition in innovation. Innovations which have grown out of the industry structure range from ice rooms and refrigerated rail cars adopted a century ago to boxed beef technology today. Thus, it would be a mistake to surgically intervene to maintain an industry configuration consistent with the static notion of competition. The top meatpacking firms today such as IBP only recently reached dominant positions, while the top firms at the turn of the century disappeared long ago in what has been termed a "perennial gale of creative destruction." This would suggest that it is unlikely that a few firms will be able to maintain their positions for very long even without government intervention.

To sum up the Azzam's message (Azzam 1998), he recommends that policy focus on industry conduct rather than structure. The aspect of conduct that policy should focus on is the degree to which competing firms may be able to coordinate their pricing without conspiring in the usual sense of the term - that is, without any overt or detectable acts of communication. The challenge is to develop creative measures, in the form of marketing institutions, to dissipate the rents from implicit collusion. Where acts of communication are overt and detectable, as was the case in the beef cartel at the close of the last century, antitrust remedies come into play. Mandatory price reporting as a policy response is discussed further below in the "State-Level Response" section.

One more recent study just released by USDA is (Hahn and others 1999). They studied monthly changes in U.S. farm-wholesale price spreads between 1979 and 1996. They did not find evidence that packers were exercising market power, although they caution that with concentration at 80 percent or higher, the potential for exercising market power in the industry does exist.

Dairy Marketing

Restructuring has been characteristic of the dairy industry at all levels in the last 50 years. Technological developments have changed the way things are done on the farm, in assembly, in processing, and in distribution. At every level economies of scale have led to fewer and larger operations. The kinds of firms have change drastically in response to cost pressure and investment pressures. Cooperatives handled 86 percent of the milk sold to plants and dealers in 1994 compared to 73 percent in 1973. For much of the century eight large specialized dairy companies dominated the marketing of fluid milk and manufactured dairy products and shaped the structure of the industry into the 1970's. Since then competition with mergers, corporate

restructuring and divestitures have taken many of them out of the business. Foreign owned companies have become more involved in U.S. dairy markets in recent years. The number of fluid milk plants fell from 10,000 in 1940 to 478 in 1995. Market power has shifted to retailers and those who service retail outlets. Cooperatives dominate the butter and ingredients markets and private firms the frozen products markets. The natural cheese markets is shared, 43 percent cooperative and 57 percent private proprietary firms in 1992. Manchester suggests that cooperatives could face significant change as public dairy programs are eliminated. And members expect them to reduce price volatility, set production quotas, better manage inventories, and expand market sales. (Manchester 1997)

Food Marketing

An assessment of the growth, conduct, performance, and structure of food marketing institutions - food processors, wholesalers, retailers, and foodservice firms - is provided in (Gallo 1998). He found that:

> "New food product introductions fell sharply in 1996. The number of new plants, consumer advertising expenditures, and common stock prices reached new highs in 1996, as did the number of mergers in the foodservice industry. Profitability from food manufacturing and retailing was higher due to strong sales, wage and producer price stability, and streamlining of operations."

Food industry mergers and acquisitions have continued at a rapid pace, setting a record in 1998 (Smith 1999).

A review of the relationship between food retailing concentration and consumer prices, power and profits yielded mixed results, especially with regard to price (Kinsey 1998). That review of the consumer impact of food retailing concentration notes that U.S. food expenditures are falling relative to household income, which calls into question the importance of concentration as a societal concern. One cited study found that greater concentration at the wholesale level was associated with lower retail food prices, probably due to economies of scale being passed on to consumers. Overall conclusions were that increased retail level concentration has been associated with both increases in prices in some food categories and decreases in others. Profits uniformly increased with concentration, but the reason was unclear. Part of the increase was attributed to lowering costs through the use of information technology and vertical coordination.

> "Casual observation implies that retail food firms engage in fierce competition and where prices are high, it is usually due to adding value and services for which consumers are willing to pay." (p. 24)

A review of the literature of wholesale meat market concentration summarizes several studies which generally raise concerns about packers' and retailers' exercise of market power to the detriment of producers (Strange and Higby 1995). They describe motivations for the move toward formula pricing of slaughter animals and the problems presented by the reduction in the share of the market that is traded by negotiation. An analysis of randomly selected meat market reports shows how wholesale price reports may be biased downward because lower quality carcasses and cheaper cuts are sold through channels that are reported while higher quality ones

fabricated for their own retail customers or into specialty cuts that do not fit into reported standard commodity categories. They provide a brief summary of the 1977 Illinois Brick Co. ruling by the U.S. Supreme Court, which held that only direct purchasers or sellers may sue a firm for damages due to the use of market power. This ruling presents an obstacle to farmers who might be in the position of being damaged by depressed wholesale prices that are passed on by packers or other intermediaries.

Federal Agencies With Jurisdiction Over Antitrust Issues

Two federal government agencies responsible for policy regarding concentration of buyers of agricultural products are the Antitrust Division of the U.S. Department of Justice, and the U.S. Department of Agriculture's Grain Inspection, Packers and Stockyards Administration (GIPSA). An overview of the Antitrust Division's role is available on the Internet at (Anonymous 99a). Text of Congressional testimony about what the antitrust laws prohibit and Antitrust's recent activities related to the meat packing industry is available at (Turetsky 1996). The responsibilities of the Grain Inspection, Packers and Stockyards Administration are described at (Anonymous 99g).

State-Level Response

The meatpacking industry is comprised of multinational firms over which the Minnesota state government and local governments have very little influence. One way in which Minnesota apparently would be able to exercise influence over the meatpacking industry would be to require mandatory price reporting on animals purchased from Minnesota producers, as South Dakota has recently done (Kloucek et al. 1999). Obviously, it is too early to predict what the eventual effects of mandatory price reporting will be. One reviewer cautions that:

> "Mandatory price reporting in a concentrated market could enhance collusion by giving more information to individual packers about the pricing behavior of their rivals. Also, if state regulations increase packer cost, packers, being multiplant firms, could always move business elsewhere and/or bid less for cattle in states that impose regulation." (see comments of reviewer #??)

Other state and local policy options available to influence livestock processors would include whether to offer financial incentives to attract new slaughter plants, and environmental regulations on slaughter plants. The entire scope of state and local policies affecting livestock production in the state is also likely to indirectly influence livestock processors, because shrinking production seems certain to ultimately result in slaughter plant closures while new plants will locate in areas that either currently have more production than can be slaughtered in nearby plants, or appear receptive to expansion.

c. contractual buying and selling arrangements,

f. price discovery and market fairness, and

One implication of marketing contracts for non-contracted producers is that the spot market becomes thinner and price discovery becomes less reliable, as discussed below. The term "captive supplies" is used to refer to the share of supply that does not go through the spot market,

either because it is transferred through contractual arrangements or through vertical ownership integration of packers into the production stage or vice versa.

(Azzam and Anderson 1996) summarizes three studies of packer integration or captive supplies on fed beef cattle prices. Concern about packer feeding is not new, as the first study was conducted in 1966 (Aspelin and Engelman 1966). They found that packer feeding in the late 1950s and early 1960s varied from 4.6 to 7.4 percent of total marketings of fed cattle, with 151-215 packers involved in feeding cattle. They found that packer-feeder volume had a significant negative impact on terminal market cattle prices in the study area, which was one of the top ten terminal markets. A regression analysis found that a 100-head increase in packer-fed shipments to the plant, on average, lowered the local average price for Choice steers relative to other markets for the entire week by about $0.06 per hundredweight. A 1991 study found similar results (Schroeder and others 1993). This study also found that price variability was not related to captive supplies. Another 1991 study found that captive supplies affected prices in Kansas but not in Colorado, Nebraska or Texas (Hayenga and O'Brien 1992). In 1992, the USDA Packers and Stockyards Administration commissioned a major study to provide a more definitive answer to the captive supplies question (Ward and others 1996). They found a:

> ".. relatively weak negative relationship between transaction prices for cash market cattle and either delivering cattle from an inventory of captive supplies or having an inventory of captive supplies from which to deliver at a later time. Results were not robust. Several versions of the models were estimated and estimations over sub-periods within the 1-year study period yielded inconsistent results. ... Price differences were found among procurement methods, but with the possible exception of price differences between forward contracts and cash market prices, observing such price differences in everyday transaction prices would be difficult." (pp. 81-82)

The USDA Grain Inspection, Packers and Stockyards Administration analyzed the hog procurement transactions during January 1996 by 4 firms and 12 plants in Iowa, southern Minnesota, eastern Nebraska, and the southeastern corner of South Dakota (Anonymous 1998d). The impact of procurement method on pricing was one of the issues studied. Results generally showed higher prices for marketing agreements and carcass merit pricing grade and yield versus spot live purchases. The spot market transactions tended to exhibit lower hog quality characteristics than the transactions under marketing agreements and forward contracts. Small sellers tended to sell on a spot market basis and received lower prices. The report of the study seems to leave unanswered the question of whether the price differential due to seller size was reasonable due to quality and transaction costs, or whether the smaller sellers were unfairly discriminated against.

An analysis of packer kill sheets provided by 300 Iowa pork producers showed that price increased with size of operation, at a declining rate (Lawrence 1996). A producer marketing 9,000 to 10,000 head per year would receive about $0.85/hundredweight more than a producer marketing only 100 head per year. Prices to producers marketing over 5,000 head per year leveled off, and the analysis showed that the price advantage peaks out at about 9,000 to 10,000 head. Backfat thickness, yield, and sort loss were included in order to adjust for quality differences.

A comparison of year-to-year hog production and price changes over the past three decades shows that prices have become more volatile (Tank). In the 1970s and 1980s, a one percent change in production resulted in a price change of around one and a half or two percent. During the late 1990s, the price response has been at least twice that great. It is unclear how much of the increased volatility is due to the increased prevalence of marketing contracts, and how much is due to other factors.

The Federal Agriculture Improvement and Reform Act of 1996 authorized the Milk Price Support Program through December 1999. The dairy price support program will terminate December 31, 1999 unless action is taken by Congress. Prior to 1981 the price of milk was supported at such levels to insure an adequate supply of milk, reflect changes in the cost of production, and assure a level of farm income to maintain productive capacity to meet future needs. Since October 1981 the support price has been established by Congress either at specific levels or by formula related to expected surplus levels rather than parity levels. The 1999 calendar year support price is $9.90 per hundredweight of milk containing 3.67 percent butterfat. To implement the price support program, the Commodity Credit Corporation offers to buy carlots of butter, cheese and nonfat dry milk at announced prices thus provides a floor for milk and dairy product prices.(Anonymous 1997f)

Agriculture Secretary Dan Glickman announced a final rule for a major overhaul of the 60-year-old federal order wholesale milk pricing system on March 31, 1999. Detailed information can be found at http://www.ams.usda.gov/dairy/reform/ (Bailey 1999). This rule is subject to either a two-thirds vote by producers in a marketing area or by producers that supply two thirds of the milk in the marketing area. If approved the ruling will take effect October 1, 1999 but may be subject to changes by Congress. These reforms help insure American dairy farmers receive a fair price and that consumers enjoy an abundant affordable supply of milk. The federal order price system set minimum prices for milk used for alternative purposes. The rule consolidates milk market areas, changes the Basic Formula Price determinants, adopts a classified pricing structure for four classes of milk, and makes some changes in the classification structure. Change were made in the Class I price differentials with lower differentials in Southwest, West, Northwest, North East, and Appalachian areas. Class I differentials would rise in the Upper Midwest and Florida. Bailey points out that a direct change in class prices may not represent a direct change in farm gate prices. The Class III price (cheese and other hard products) in this rule will be lower than the current BFP (Basic Formula Price), and in the Upper Midwest processing plants have regularly bid pay prices above the minimum government prices.

USDA began tracking the mail box price milk producers receive within Federal Milk Market Order areas. Mailbox prices account for all payment for milk, amount and quality premiums, performance bonuses, fat and or protein premiums, as well as deductions for promotion, hauling, capital retains, and coop dues. The average mailbox prices received by producers were significantly higher in these orders: Upper Midwest $1.72, Chicago Regional $1.53, Iowa $.99, Florida $.68, Nebraska-Western Iowa $.57, and Southwest Idaho-Eastern Oregon $.55. The higher price over minimum blend prices in these areas in 1998 were a result of competition for milk by cooperatives and other buyers.(Hoards Dairyman Staff 1999)

The 104th U.S. Congress in 1996 gave conditional consent to the Northeast Interstate Dairy Compact (Section 147 of the Agricultural Market Transition Act, title 1 of Public Law 104-127;

7 U.S.C. 7256). This act provided consent for the states of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont to regulate milk prices for their farmers. Milk pricing is the only agricultural commodity for which congress has given consent to the use of interstate compacts. The compact works with the federal order pricing system as a basis for its pricing mechanism. The higher farm level prices are passed to the consumers in the price they pay for fluid milk. A Compact Commission fixes a price that exceeds the federal order price for fluid milk, compact over order premium. Ken Bailey (reference?) recently reported a study estimating the regional impacts of a Southeastern States compacts that is current receiving political support from that region. His assumptions for these estimates were taken from the Northeast compact experience. The estimated impacts for the state of Missouri to be a part of the compact are as follows: increased farm marketings in response to a higher price, reduced consumer purchase of fluid milk due to a higher price, and an increase in portion of milk used for class 3 which impacts the price of class 3 milk. The estimated impacts on a non-compact state like Wisconsin are: reduced milk marketing due to a price decline, a reduction in the federal order blend price, small increase in fluid milk consumption with a small decline in price, and a total market reduction in the revenues paid to farmers and collected from retail sales. Dairy compacts and Federal Milk Market Order Reform are two current milk marketing issues under contentious regional debate. Upper Midwest representatives in Congress submitted H.R. 744 submitted a bill to rescind the Northeast Dairy Compact (Sensenbrenner and others 1999).

d. access to markets, and

g. access to inputs, such as credit and genetics

Small, independent producers' access to markets for both farm products and inputs is a concern that is often expressed in the farm press and elsewhere. Market access is mentioned in some academic publications by way of justification for research on more specific issues such as what affects hog prices (Lawrence 1996) or simulating the welfare effects of vertical integration (Pritchett and Liu). A number of studies have been done on the impacts of international trade agreements on access to foreign markets for various industries. One such study dealing with agriculture is (Anonymous 1997d). None of these studies seem be very closely related to the issues being addressed in the GEIS, so the others will not be cited here. There appears to be little academic research specifically on market access as it relates to the livestock industry.

Exports have been a relatively minor market for U.S. dairy products. U.S. milk prices have historically been well above the World market price. thus the price of the major export products, butter and dried skim milk, have not been competitive. (Historical Perspective on World Dairy Prices 1979-1998, http://www.fas.usda.gov/dlp/circular/1998/98-12Dairy/prd&tr-html). Europe is the largest dairy exporter with 45- 50 percent of the markets. The strong European presence in dairy exports is more related to the government subsidization of dairy products in the World market rather than low cost of production. The U.S. has only 10 percent, New Zealand 22 percent and Australia 9 percent. Dobson states that the U.S., New Zealand and Australia will move to displace Europe in the world trade of dairy products in the next 10 years as European subsidies decline. The European Union agreed to reduce export subsidies for cheese, butter and nonfat milk in the Uruguay GATT agreements. They will reduce subsidized cheese exports by up to 25 percent by the year 2000. These changes are expected to bring export competition at more fair prices reflecting world supply and demand. Dobson points put that U.S has fewer

constraints for expansion but will face substantial competition particularly in Asia. He points out that the New Zealand Dairy Board is a monopoly that provides product differentiation, vertical integration and early movement into new markets. (Dobson 1996)

An emerging concern is being raised relative to the privatization of information and the potential social, economic, and environmental impacts that may result. Various authors suggest this to be an important issue that deserves attention by analysts, advocates, policy makers, and those with a direct economic stake in agriculture. These concerns were the focus of a 1995 workshop, Privatization of Information and Technology Transfer in U.S. Agriculture. This workshop was organized to stimulate research and debate on the restructuring of agricultural information systems and the implications of the changes taking place. Three principal themes came from this workshop; 1) Institutional relations governing development, control and application of information in agriculture are changing at an accelerated pace, 2) Current and future processes through which knowledge is created and information applied in agricultural production systems will be developed through synthesis of political, economic, institutional, and technological considerations, and diminished public sector involvement and 3) Increased private sector responsibility for information development and dissemination in agriculture is significant. An excellent discussion of these issue can be found in the workshop proceedings (Wolf 1998).

e. terms of trade

The terms of trade between agriculture and the rest of the economy has been a long-standing issue, often referred to under the heading of "parity." The parity price formula was written into the Agricultural Adjustment Act of 1933 (Brandow 1977). Price parity ratios are calculated by the USDA National Agricultural Statistics Service and published in the monthly Agricultural Prices publication under the authority of the Agricultural Adjustment Act of 1938, as amended (Anonymous various issues), page A-25. The overall parity ratio for U.S. farmers for January 1999 stood at 41 (1910-41 = 100). A parity ratio less than 100 means that the average per unit purchasing power of all farm products is less than half that during the 1910-41 period (page B-2). A major difficulty in interpreting the parity ratio is how to account for improvements in productivity. The annual average increase in productivity from 1948 to 1994 was 1.94. The January 1999 parity ratio, adjusted based on productivity trend for the prior 15 years, stands at 1041. This suggests that farm inputs are 25 times as productive as in 1910-14, indicating that the ratio of prices received to prices paid is around ten times as high now as in 1910-14 after considering the increase in productivity. The procedure used by USDA to measure agricultural productivity trends is explained in (Ahearn and others 1998).

A description of the agricultural economics profession's response to the parity issue through 1971 is provided in (Brandow 1977). Full parity prices were foreseen in a 1947 report as leading to unmarketable surpluses that would in turn require production controls and subsidies, to which many economists were opposed. The controversy over free markets versus government programs spilled over into discussions of quantifying an equity norm for agriculture. During the 1950s and 1960s farm policy literature contained the idea that a suitable policy goal was rates of return on labor and investment on efficient farms that were equal to rates earned on comparable resources outside of agriculture.

Measurement of rates of returns on land and other investments and their use for policy purposes can cause circularity problems, however. In the 1980s, USDA was required to calculate costs-of-production indicators that the Secretary of Agriculture could use to set support prices for major crops. (Harrington 1983) explains the difficulties encountered with the procedures used at that time.

> "In general, the return to an input should equal the return it would earn in its next best use - its opportunity cost. However, what is the next best use of a specialized input, such as agricultural land? Economic theory also says that costs of specialized inputs cannot be determined independently of the demand for the product. The opportunity cost concept is difficult to apply to all specialized inputs, including those specialized to agriculture. ... If the difficulties inherent in the imputation lead to cost estimates that are too high or too low and if these estimates influence target prices, artificially induced price spirals may result." (p. 1)

Bearing in mind the circularity issue, a rough comparison of rates of return can be made by comparing the rates of return on equity (market value) experienced by farms in the Southwestern Minnesota Farm Business Management Association (SW FBMA) (Olson and others 1999) and reports for earlier years, with the ratio of profits after income taxes (annual rate) to stockholders' equity experienced by all U.S. manufacturing corporations over the past ten years (Council of Economic Advisers 1999), (Table 16). The farms' rate of return on equity at market value has been about five percentage points less than that of manufacturing firms on average, and was less in eight of the most recent ten years. As another comparison, (Gallo 1998) provides after-tax profits as a percentage of stockholders' equity for food processors and retailers for the period 1986-96. Processors' returns ranged from 13.5% in 1993 to 20.9% in 1988, and were generally flat over the period. Retailers returns generally rose over the period, ranging from 5.3% in 1989 to 18.5% in 1994. It should be noted that the farm rates of return are on an accrual-adjusted basis considering beginning and end-of-year market value balance sheet net worth changes, so to that extent include both operating income and unrealized capital gains on land and other assets.

One caveat that applies to this comparison and later discussions is that the SW FBMA farms are not representative of all farms in their area, although their data is often used because it is the best data available. They tend to be larger, a higher proportion of their land is rented, and they tend to be more efficient than the population of all farms (Andersson and Olson 1996).

Table 17 shows rates of return on equity experienced by the association farms broken out by farm type for the period 1994-98. The farm type rates are only published for cost basis balance sheet data, rather than on a market value basis as in Table 16, so the numbers are not directly comparable between the two tables. The 1994-98 average rate of return across all farms is five percent when calculated on a cost basis compared to seven percent when calculated on a market value basis, which would indicate that about two percentage points of the Table 16 rates are due to capital gains from asset appreciation. Also, cost-basis asset values on the balance sheets are likely to be less than market values when some degree of inflation is present, which would tend to make the cost-basis rates of return higher than market-based rates for the same income levels.

Table 16. Rates of Return on Equity on Southwestern Minnesota Farm Business Association Farms Compared to All Manufacturing Corporations, Food Processors, and Food Retailers, 1989-98

	SW FBMA	All Manufacturing Corporations	Food Processors	Food Retailers
1989	11%	13.5%	17.0%	5.3%
1990	15	10.6	16.2	11.3
1991	3	6.2	17.6	14.5
1992	6	2.1	15.7	9.0
1993	3.5	8.0	13.5	11.3
1994	4.4	15.8	17.7	18.5
1995	9.1	16.0	18.5	17.2
1996	9.5	16.7	19.4	17.4
1997	9.7	16.7	a	a
1998	1.6	19.6	a	a
1989-96 average	8%	11.2%	17.0%	13.0%
1989-98 average	7%	12.5%		
1994-98 average	7%			

[a]Food processor and retailer data was not available for 1997 or 1998.

The "All SW FMBA Farms," "Hog", "Crop," "Crop-Hog," and "Crop-Beef" columns are for the southwestern association. The "SE FBMA Dairy" column is from the southeastern association, which has more dairy farm members than does the southwestern association. The farm types are based on having 70 percent or more of gross sales from that category. The number of farms included varies from year to year. In 1998, there were 210 total farms in the All "SW FBMA Farms" average, including 10 hog farms, 71 crop farms, 37 crop-hog farms, 24 crop-beef farms, and 59 other farms. There were 16 dairy farms in the SE FBMA average. It is apparent that the hog, crop and beef farms experienced relatively good years in 1995 and 1996, while 1997 and 1998 have been much less profitable. The financial performance of the dairy farms was more favorable in 1998.

Table 17. Rates of Return on Equity (Cost Basis) on Southwestern and Southeastern Minnesota Farm Business Management Association Farms by Farm Type, 1989-98

	All SW FBMA Farms	Hog	Crop	Crop-Hog	Crop-Beef	SE FBMA Dairy
1989	11%	19%	10%	12%	6%	6%
1990	15	22	9	21	12	8
1991	3	4	2	5	4	8
1992	6	7	3	8	3	7
1993	2	11	1	1	-1	3
1994	3	-3	7	5	1	7
1995	13	22	14	18	8	5
1996	12	22	11	16	11	6
1997	5	11	3	3	8	3
1998	-6	-36	0	-17	-11	14
1989-98 average	6%	8%	6%	7%	4%	7%
1994-98 average	5%	3%	7%	5%	3%	7%

Source: Annual reports of the Minnesota Farm Business Management Associations, such as (Olson and others 1999).

h. lending practices

It is assumed that the main interest here is how lending practices might differ to different types and sizes of livestock operations, how any such differences might affect industry structure, whether any such differences are fair and economically justified, and how government policy might be changed to better address societal goals such as economic efficiency and equity.

Agricultural finance has been a major part of the discipline of agricultural economics since its inception, and there is a considerable body of agricultural literature. One source of refereed literature on agricultural finance is (Eddy L. Ladue), but other articles are found in (American Journal of Agricultural Economics) and other journals. Various articles address different aspects of the lending decision such as the relative degree of risk involved in different types of farms, and ways of assessing risk such as credit scoring models (Novak and LaDue 1997).

One source of basic descriptive information is a recent report from the US Small Business Administration that rated the "small farm friendliness" of all commercial banks and bank holding companies. They defined small farm loans as loans under $250,000, and assigned a decile (10 percent) ranking based on 1) the ratio of small farm loans to total bank assets, 2) ratio of small farm loans to total farm loans, 3) total dollar amount of small farm lending, and 4) total number of small farm loans. The ranking was based on data from the banks' June 1998 "call reports" to banking regulators. The study found that the smallest banks had the largest share of small farm loan dollars, and raised concerns that recent bank consolidations are reducing the number of small banks so that there are fewer small banks remaining to lend to small farms. They found that the stock of small farm loans had increased in the past year while the number of such loans declining, so that either the average loan size is increasing or many small loans have been repaid.

One paper in 1993 indicates that the larger scale of the newer swine operations has attracted the interest of investors and lenders from around the world, such as Rabobank in Holland (Braaksma 1993).

A source of information on agricultural credit conditions and analysis of current economic issues is the set of Economic Review publications published by the regional Federal Reserve Banks, which is available in hard copy and on the Internet. The Kansas City bank in particular publishes a great deal of information on agricultural issues (Anonymous).

USDA has a series of short, nontechnical reports on their web site which discuss federal government involvement in farm lending and ways in which federal action could improve efficiency (Collender 1998). They quote Department of Justice findings that 93 percent of rural banking markets are considered non-competitive in that banking business is concentrated among few banks. Suggested federal actions include:

- harmonizing charters and regulations for government-sponsored enterprises such as the Farm Credit System and the Federal Agricultural Mortgage Corporation to reduce market segmentation,
- regulatory reform for all lenders,
- encouraging entry into concentrated markets through nontraditional mechanisms including electronic funds transfers and telecommunications, and
- continued antitrust vigilance.

Federal estate tax changes are suggested to make it easier to transfer family farm businesses across generations, although they find that only about one-third of heirs in each generation choose to operate inherited family farms.

Another report in the USDA series addresses beginning farmers' credit needs. They suggest that traditional credit programs have limited potential to assist young low-equity farmers, because they are ill-equipped to deal with the increased risk that accompanies high leverage. They suggest tax initiatives such as lowering capital gains taxes on land sold to beginning farmers, tax-exempt or tax-deferred "aggie" savings accounts. They suggest that state statutes be changed to facilitate beginning farmers' access to equity capital as a substitute for debt. Limited partnerships, subchapter S corporations, and limited liability corporations are suggested as ownership forms that would make it easier for investors to purchase an ownership interest in the farm and limit their liability to the amount of the investment. This is the flip side of the often-heard argument that the non-farm investors would unfairly compete with family farmers.

A more in-depth discussion of structural change in agriculture, how it is affecting lenders, and policy implications is presented in (Duncan and Stam 1998). They trace some of the history of the traditional farm lending industry, past policy responses. They expect that the emergence of non-traditional credit sources and foreign lenders will compete with traditional ones. One area of concern is the possible impact that failure of large-scale integrated agricultural firms would have on the rest of the nation's food and fiber sector. There is currently no consensus on what if anything should be done to protect against such an eventuality.

Question D5. What is the current situation and what are the changes taking place in the ownership and control of livestock in Minnesota:

D5a. who owns the livestock and livestock facilities and what is the significance?,

D5b. what are the current trends in type of ownership by animal species, facility size and regional location?

D3e. How are livestock businesses different from and similar to non-agricultural businesses with respect to the following factors, and what are the implications of these differences: patterns of ownership and control

It is not clear what classification of owners is of interest to these questions. A measure was debated and almost passed in the Minnesota House of Representatives this session to allow different feedlot regulations for farms where the owners resided, compared to farms where the owners did not reside (Anonymous 99e). That debate suggests that classifying owners by local community of residence might be of interest. On the other hand, the Minnesota Corporate Farming Law differentiates between Minnesota farmers and others, suggesting that a classification based on state of residence and principal occupation might be of interest. Unfortunately, our investigations to date have not turned up any publications that classify either livestock businesses or non-ag businesses according to local community or state of residence, or principal occupation of the owners, except for (Freese 1998). That report, published annually, describes the 50 largest U.S. pork producers and lists the states in which they operate.

According to their data, four of the 50 largest producers are headquartered in Minnesota: Pipestone System/Hawkeye (17), Christensen Farms & Feedlots (18), Holden Farms (24), and Wakefield Pork (39). In addition, Purina Mills (Koch) (11), Farmland Industries/Alliance (16), and Consolidated Nutrition (42) operate partially in Minnesota. The report does not go into detail on the ownership and control of these operations. Pipestone/Hawkeye is reportedly organized as a number of separate corporations whose management is coordinated by a veterinary clinic. Each corporation operates a sow unit jointly owned by producer-shareholders who receive early-weaned pigs and finish them in their individual operations. The other large operations in Minnesota are believed to be held under a variety of different ownership arrangements, but detailed information was not available on them.

Two classifications that are available are: 1) type of legal organization (proprietorships, partnerships, and corporations), and 2) ownership by foreign persons versus U.S. citizens. USDA monitors foreign ownership of agricultural land, but does not monitor ownership of livestock businesses as distinct from other farms. As of December 1995, foreign persons owned slightly more than one percent of all privately held agricultural land in the U.S. (Krupa 1996)

There are dramatic differences in types of legal organization used by farms versus non-farm businesses. In 1997 corporations made up 18.8 percent of all non-farm businesses but generated 90 percent of all non-farm business receipts (Anonymous 1998a). Corporations with more than ten shareholders made up only 0.3 percent of Minnesota farms in 1997, and accounted for 4.2 percent of the market value of products sold (Anonymous 1998c). (Allen and Lueck 1998) use a theoretical model based on a trade-off between moral hazard incentives and gains from specialization to explain why farming has generally not converted from small, family-based firms into large, factory-style corporate firms. They compare their model to empirical evidence that family-controlled farm production has narrowed to those stages that include the most biologically based aspects of farming. Changes in livestock technology, which largely eliminated nature, have allowed factory-corporate production to dominate in feedlot cattle, hogs, and poultry.

Another study that mentions farm ownership is (Wilson and others 1993). They studied the risk perceptions and management responses of managers of large Arizona dairy farms. They found that firm size, ownership structure, and age were consistently important in determining the likelihood of selecting a wide range of important perceptions and management responses.

Broadening the Control Question

It might be useful to broaden the discussion of control from control of livestock in Minnesota to control of the food system generally. Boehlje and Schrader argue that a fundamental issue in any negotiation-based coordinated system is the point (or points) and source of power or control. Who dictates, or has the most control, over the performance of the system, of the sharing or risk and rewards? And what is the source of that power or control? They argue that there are two fundamental points of control and one fundamental source of power in a negotiation-based coordinated food production and distribution system. The first point of control is the end user or consumer and those firms that have intimate contact with the consumer. The second point of power is the raw material suppliers, especially suppliers of inputs with the fewest substitutes - the genetic material in plant and animal production, the seed and breeding stock. In both cases,

the source of this power is knowledge. They also argue that the food system is at an early stage in the process of shifting to contract/ownership coordination, and there may be an opportunity for organizations such as very large producers or producers' cooperatives to assert control and offset the perceived advantage of firms at the consumer or raw material end points of the system.

D5c. what legal and business structures are used?

One of the concerns about livestock operations operated as corporations or other liability-limiting forms of business organization appears to be that the limitation on liability allows owners and managers to take more risks with environmental and other practices than they would take as sole proprietors. It is probably not practical to sort out the impact of this liability issue from the impact of firm size per se in an empirical study – at least it has not been done to date. Discussions of when and how the corporate form of business organization was first written into law, and the concerns that were expressed then about corporations abusing their economic power, can be found in chapter 4 of (Korten 1995) and on pages 25-26 of (Strasser 1989). This concern is not limited to agriculture and probably would have to be addressed at an economy-wide and national if not international level.

D5d. who makes the decisions over the practices of livestock operations of different kinds in Minnesota (owners vs. renters)?

We were not sure how to address the "owners vs. renters" dichotomy in this question. In the late 1970s, several studies addressed the question of whether rented cropland was being as well protected from soil erosion as owner-operated cropland was. A quick search did not turn up any publications on this question more recent than about 1985, so it appears that interest in this topic appears to have declined. None of the publications seemed to focus specifically on livestock operations, in any case, so we will not cite them here. The "renters" category seems less relevant to livestock issues than it does to crop issues. In livestock production, it would seem that a more relevant dichotomy might be something like:

- independent producers vs.
- producers with production contracts (own facilities but not the animals) and their contractors vs.
- owners of larger operations, managers, and their employees who do not have an investment in the operation.

The decisions of interest also seem unclear. In the 1970s studies, the focus seemed to be on decisions that affected soil erosion and conservation. Conservation issues might also be of interest for livestock operations, especially with regard to manure management practices. Other areas of interest might be animal welfare and food safety.

One publication that seems to relate most closely to this question is a report on management decisions made by U.S. farmers which was based on data from USDA's Farm Costs and Returns Survey(Perry and Johnson 1996). They include graphs showing the percentage of farms where the decisions were made by: 1) the operator, 2) the spouse, 3) both, and 4) someone else, with the decisions classified as:

- Buy/sell land,
- Buy/sell equipment,

- Scheduling,
- Marketing,
- Off-farm job, and
- Taking up a new practice or new crop/livestock.

That report also contains graphs showing the percentage of farms and of value of production with:

- partnerships or family corporations,
- share rent landlords,
- production contracts,
- both landlords and contracts, and
- non-family corporations and cooperatives.

They found that about 73% of farms and 26% of production was from single-family farms with none of these other arrangements, and that the prevalence of the other arrangements decreased in the order listed above. The report did not, however, provide results for livestock operations only, or discuss how differences in decision-making affected performance. Our search of the economics literature to date has not turned up any other publications very directly related to these issues.

Question D6. What motivates livestock producers and processors to start, continue, expand, and quit business? What are the characteristics of those starting, continuing, expanding, and quitting?

D6a. What motivates livestock producers and processors to start, continue, expand, and quit business? and

D6b. What are the characteristics of those starting, continuing, expanding, and quitting?

Minnesota workers studied dairy herds that made significant increases in the total milk marketed from the farm in the period 1989 to 1993. (Stahl 1999) About 80% of the increase was achieved from increasing cow numbers and the remainder from improved productivity. The herds chosen for this study were from the top 100 DHIA herds making the largest increase in milk sold. The fifty herds in the study had an average increase in milk marketed of 90% and increased herd size by 51 cows. Fifty percent of these farms were partnerships and the balance was single family farms. These farms made major changes such as animal housing, milking systems, feed storage, manure handling, hired labor, record keeping, feeding program, use of outside expertise, etc. The primary reasons these farms made these changes were: increase income, improvement in lifestyle, efficiency of operation, modernize facilities, and desire for a management challenge. Eighty four percent indicated they had met their goals. They reported the areas of greatest difficulty in this transition period were in rank order: uncertain economic times, limited access to capital, employees difficult to find, expert opinions differed, environmental regulation, and development of financial plans for financial institutions.

Fundamentally, the motivation of producers to raise livestock probably has not changed since colonial times – to add value or provide a market for their crops. (Lawrence 1997) describes characteristics and motivations of Iowa producers who quit pork production between 1992 and 1996. They averaged 48 years old, had average annual marketings of 745 head, and had relatively little money invested in facilities. Economic reasons (low returns or high cost) ranked

above other reasons such as access to markets or pressure from neighbors as reasons for stopping production. Half of the producers indicated that they had experienced health problems while raising hogs.

There is a line of reasoning that the commodity programs of the past few decades, by stabilizing crop prices, may have reduced the risk associated with specialized crop and specialized livestock operations, compared to diversified crop-livestock operations. The stabilizing effects of the commodity programs were cited as forces driving the development of specialized broiler operations and beef feedlots in the 1960s and 1970s (Reimund and others 1981). The rationale is explained in (Lazarus 1995):

> "The rationale is that the effective price that is being supported (what the crop producer gets) is the sum of the market price for the grain plus the deficiency payment. But the livestock producer only pays the market price. If the market price is less than it would be without the program, the crop producer is not hurt as long as the deficiency payment makes up the difference. The other main feature of the feed grain program - cropland setaside - restricts supply so that deficiency payments are minimized. Still, deficiency payments have been substantial in some years. A major input risk for livestock producers has been reduced to the extent that feed prices have stabilized. Without such stability, it might have been more difficult for large, specialized livestock operations to develop."

The 1996 farm bill converted the deficiency payment feature to a fixed transition payment no longer linked to current market prices, so that there is less of a stabilizing effect on crop producers' income. There is also less importance placed on commodity loans for keeping crops off the market and stabilizing prices, so livestock producers are facing more volatile feed prices than previously.

Our impression is that many of the new swine finishing enterprises that were set up in Minnesota in the 1990's were undertaken by formerly specialized grain producers in response to low grain prices. That was the case in one specific operation's situation, as discussed in (Watson 1993). At more of an aggregate level, there are the discussions of the motivations for the development of integrated food supply chains in Mike Boehlje's materials, the Heffernan paper, and elsewhere.

There is a considerable body of literature on motivation for the development of tighter vertical integration or contractual coordination linkages in the economy generally and in the livestock industry specifically. The question is unclear about the extent to which " ... start, continue, expand, and quit business ..." includes the issue of packers integrating into production, large producers building their own packing plants, etc. One publication which provides a brief review of the theory and empirical evidence from a survey of large hog producers and processors is (Lawrence and others 1997).

Question E1. What are the economies of scale (including diseconomies) related to livestock raising, and what are the implications for size and type of production system?

A clarification of terminology - Economies of size and scale are often used interchangeably, but they are somewhat different concepts. *Economies of size* relate to the reduction in average total cost associated with varying levels of output, where the proportional relationship between production resources is not held constant. In other words, as farms get bigger, the relative proportions of land, labor, and capital typically change. *Economies of scale* relate to proportionate increases in all production resources as output increases. For most farm situations, "economies of size" is a more commonly used concept, in that resource ratios typically change as farms become larger. (Harsh and others 1981), page 57 and (Hallam 1991). We will assume that economies of size are what is of interest to the GEIS.

One point which needs to be kept prominent in the discussion is the fact that increasingly, livestock businesses operate with *multiple locations* under *one business entity* or firm which controls the multiple locations through direct ownership, contracts or other business arrangements. In a multi-location livestock operation, size can be calculated based on the number of livestock at the same location or the number controlled by the same firm. For some environmental issues such as volume of a potential manure spill, the location size seems most relevant. For other issues such as market power, the firm size is probably what matters.

The agricultural economics profession has focused a great deal of attention on the theoretical and empirical aspects of economies of size and scale for many years. Two collections of papers were published in 1984 (Center for Agricultural and Rural Development 1984), and 1993 (Hallam 1993). Empirical studies of economies of size in agriculture have generally found the cost curve to be "L"-shaped. Changes in the structure of agriculture over time are not necessarily consistent with this cost structure. These differences can be reconciled by appeal to external, non-size factors, and to difficulties in correctly measuring size economies (Hallam 1991).

Hallam lists three reasons to be interested in economies of size:

1) International competitiveness and terms of trade – economies of size in one country may be exploited to maximize domestic welfare, while economies of size in another country may be stifled and an industry protected to attain other social goals.

2) The normative issue of the desirability of the family farm – if research shows that there are no economies of size for firms larger than the "typical" family farm, then policies that protect this entity are more palatable to those who argue for economic efficiency as a primary objective.

3) Understanding economies of size may help policy makers, firms and consumers to predict the changing structure of U.S. agriculture.

In summarizing studies relating to economies of size and scale in agriculture, Hallam draws two general conclusions: 1) there do not seem to be significant economies of size for mixed crop farms, the most common farm type; and 2) the cost curve does fall, but remains rather flat over acreage compatible with the "average" family farm. Cost curves for livestock producers fall more sharply and over a larger range of output levels. This evidence would imply that firm size

should be fairly constant. This is not in accordance with the dramatic decrease in farm numbers and increase in farm size over the past forty years. The difference between changes in industry structure and those predicted by the "size economies" theory need to be reconciled.

There are many reasons for these differences:

- pecuniary economies (quantity premiums for selling in larger quantities, and quantity discounts in purchasing inputs,
- economies realized as the industry as a whole expands and specializes,
- technical change that continually moves the entire cost structure in favor of larger firms (the cost structure is "L"-shaped but moves lower and to the right each period due to technical change),
- improvement in managerial technique and information use such that relatively minor technical economies are parlayed into significant operational economies, and
- opportunity costs outside the agricultural sector – if wage levels outside of agriculture are on the rise, then farmers may tend to leave the sector until wages equalize. This can result in farm size increases, especially if equipment efficiency increases at the same time.

He points out that differences in farmers' values and goals may have a major impact on agricultural structure. If the cost curve is only mildly downward sloping, then producers who value the farming lifestyle will accept a slightly lower return to labor and management and thus make small firms with higher economic costs fully compatible with large firms that have lower costs. The inaccuracies in measuring size economies and the relative flatness of most measured curves do not allow the distinguishing of these possibilities.

A number of potential problems in measuring economies of size were also identified, which are categorized into those which relate to cross-sectional studies, those which relate to normative studies, and one which relates to any study where commodities or firms are aggregated:

- Cross-sectional studies (such as farm record summary data sorted by size, and USDA Farm Costs and Returns Surveys) may encounter problems due to lack of homogenous technologies across sizes, and firms may not be fully exploiting their technology at a given point in time. As firms learn, costs drop and the curve shifts. Also, all firms may be producing at the point of minimum average cost so that there are no observations in the upward sloping portion of the cost curve, masking any size economies of diseconomies that are present.

- Normative studies (economic-engineering, budget or mathematical programming models) can only represent technologies that are specified available by the researcher. There may be mis-specification of the technologies, if some are left out. If data from cross-sectional surveys are used to obtain technical coefficients and construct technologies, firms with the lowest cost of production may be considered outlyers and left out.

- Most empirical models involve aggregation over commodities or firms, often in ad hoc ways. The results may be biased if such aggregation masks economies of scope and jointness.

One additional concern which a reviewer pointed out is not very well articulated by Hallam - how the farm operator's labor and management is represented. It is often argued that an

important motivation for farms getting bigger today is to generate greater income or net return to the operator's labor and management. For increased size to generate greater income implies that labor may have been under-utilized previously, and/or that labor efficiency is being improved through increased mechanization, automation, or more effective management. This phenomenon may or may not be captured in the study depending on how labor and management data is represented.

Economic efficiency, as measured by per unit cost of production, is one component of the income revenue generated by the farm business to support the family income and life quality goals. Conlin used the following equation to illustrate the principles:

Profit = (Price-Cost) * no of units marketed.

Decisions for managing improved profitability of the farm business consist of increasing price received, reducing cost of production , and or increasing units marketed. These components are interdependent in that cost may be reduced by increasing number of units produced, which leads to economies of size as described by the L-shaped curve discussed above. There also may be some improved market price advantage by marketing more units. Obviously, marketing more units where the cost per unit is more than the price received will result in larger revenue losses. Diseconomies of size would suggest the cost of production increases at certain size levels, or there are diminishing returns with increases in size. In spite of diminishing returns on a per unit of production, total profit will increase with more units marketed up to the point where the cost of the next unit is equal to the revenue generated by that unit. This is the concept of marginal returns. Maximum profitability of the business is where marginal returns equal marginal cost. Therefore the lowest cost of production is not necessarily the most profitable for the business.

Readers must also be cautioned that concept of an L-shaped curve relates to aggregated data from large numbers of farms or perceived representative farm situations, but that for any individual farm the points on the curve will vary as a result of many individual farm and human factors. Farm business managers continually apply new technology and make changes to improve their businesses and survive in a competitive environment. These changes impact the cost of production and potential economies of size and scale.

Empirical Studies Relevant to Minnesota

Aggregate Analysis

(Peterson 1997) analyzed economies and diseconomies of size at a very aggregate level across all farms in ten Corn Belt states, using data from the 1987 Census of Agriculture. He points out that scale economies must be a temporary, disequilibrium phenomenon since payments to factors will exceed output. Obviously, this situation cannot persist indefinitely. He performed a regression analysis with the dependent variable being out-of-pocket expenses per dollar of sales, using nine size classes from $2,500 sales and less, to $500,000 sales and over. He found that economies of size were evident in the data when using only farm sales as the output variable. When 1) an implicit rental value is placed on the farm dwelling and added to sales, 2) differences in corn yields across farm size classes were netted out, and 3) days of off-farm work were factored in, diseconomies of size became evident. The result is interesting, although we are not sure how

useful the result is to livestock industry issues given that he aggregated all farm types together. We are also not sure how valid his assumption is that corn yield differences are due to differences in soil type rather than management. Also, while days of off-farm work helped explain differences in the expense ratio, he did not have data on off-farm earnings, which might have been a better indication of family well-being. This publication was cited in the January 1998 report from the USDA National Commission on Small Farms to justify their call for greater support for small farms.

Hog Farm Profitability

For the pork industry, possible sources of information on economies of size relevant to Minnesota include:

- farm business record summary programs,
- surveys by the USDA National Agricultural Statistics Service, and
- surveys of mid- to large-sized pork producers conducted in recent years by researchers at Iowa State University and the University of Missouri.

The most relevant farm business record summary programs are:

- the Southwestern Minnesota Farm Business Management Association annual summaries [see (Olson and others 1998) for the most recent report],
- the Minnesota State College University Farm Management Program annual summaries (see (Anonymous undated) for the most recent report), and
- the annual reports of the Iowa Swine Enterprise Record Summary Program conducted by the Iowa State University Department of Animal Science (Anonymous undated).

None of the current published annual reports from any of these three record summaries include swine enterprise averages by size of operation, which would be needed to analyze economies of size. It would probably be possible to obtain averages by size from any or all of the three programs if a small amount of funding were provided to pay for the staff time to do the necessary computer runs. There is another problem, however. The most rapid growth in the swine industry today appears to be coming in the very large or "mega" operations of at least 50,000 head marketed per year or roughly 2,500 sows or more. We assume that what the GEIS is most interested in is how profitability of these megas compares to the more traditional, small- to mid-sized, diversified, crop-hog operations. The problem is that the megas do not generally participate in university farm business summary programs and are not represented in the averages.

Another source of economies of size data is the Farm Costs and Returns Survey conducted by the USDA National Agricultural Statistics Service and the USDA Economic Research Service. The most recent report with a size analysis is (McBride 1995), based on the 1992 survey. The farrow-to-finish hog operations are analyzed in four size categories: fewer than 500 head sold or removed under contract, 500-999 head, 1,000-2,999 head, and 3,000 head or more. The largest

size breakpoint thus represents only around 150 sows, so the data is not useful in comparing the megas with the traditional mid-sized operations.

The only source covering the megas is the set of surveys of mid- to large-sized pork producers conducted in recent years by researchers at Iowa State University and the University of Missouri. The most recent report is (Lawrence and others undated) It was based on useable responses from 2,030 producers from the nationwide Vance Publishing mailing list of pork producers compiled by *Pork* magazine, of which 391 marketed 10,000 or more annually. Producers were not asked for detailed cost records. Rather, they were asked to identify their minimum "stay in" price, defined as the hog price they would need to stay in business for the next 3-5 years if the central Iowa corn price was $2.50 per bushel. Their responses likely reflect their variable cost of production and their perceived opportunity cost for resources used in pork production. Readers are cautioned not to rely too heavily on this data, because as one reviewer points out, there are many factors that influence whether a producer "stays in."

"Stay in" prices vary widely for all size classes, but especially for the smaller ones. The responses indicate that at very low prices of $36 per hundredweight, a larger share of the smallest producers would stay in compared to larger producers (Table 18). The best estimate of an average cost of production might be the price where operations producing at least half of the size class' hogs would stay in. By that measure, the megas are likely to have a production cost advantage of perhaps $1-$3 per hundredweight.

Table 18. Willingness to Stay in Production Until 2002 by Size Group at Each Hog Price

Size class	Marketings by Size Group and Hog Price				
1,000 hd.	$36	$39	$42	$45	$48
	(percent of all hogs produced by operations in the size class)				
1-2	16.6%	42.0%	66.0%	85.4%	93.9%
2-3	13.0%	37.3%	68.1%	90.9%	95.7%
3-5	12.7%	38.5%	67.4%	82.8%	97.1%
5-10	10.2%	37.6%	71.9%	91.2%	97.3%
10-50	9.6%	33.2%	62.2%	87.2%	96.7%
50-500	6.0%	21.0%	61.0%	96.0%	100.0%
500+	9.0%	51.0%	89.0%	98.0%	100.0%

Source: John Lawrence, Glenn Grimes, and Marv Hayenga. Production and Marketing Characteristics of U.S. Pork Producers, 1997-1998, Staff paper 311, Iowa State University, Ames, Iowa.

Another widely cited source of information on economies of size in pork production is (Anonymous 1995). This contains budgets for four sizes of farrow-to-finish swine operations from 150 to 1,200 sows, and estimates the impacts of several specific technologies on profitability. They found greater economies of size than the Grimes et al. Survey would indicate. Total production cost for a 1,200 sow high technology operation was $34.25 compared to $40.54-47.88 for a 150 sow operation depending on the level of technology used and performance achieved on the smaller operation. The cost advantage for the larger size was then in the range of $6-14/hundredweight. A companion paper compared a 3,400 sow operation with 250 and 650 sow sizes (Hurt and others 1995). They found that the 3,400 sow size resulted in

$4.28/hundredweight lower production costs than with 250 sows, and $1.86 less than with 650 sows, under Midwestern U.S. conditions. They also found that the Midwestern 3,400 sow size had a cost advantage over the same size operation in North Carolina, because of lower feed costs. The data sources for the Purdue budgets are not documented in detail. It is not clear how directly their costs were based on record summaries or surveys, and how much was based on expert opinion and anecdotal information. There is always the chance that any budget study may leave out certain costs or management issues which may affect the results that average farms may experience. As a result, surveys such as the Lawrence et al. survey discussed earlier, or record summaries may be more reliable indicators of overall industry conditions when available.

Table 18 shows that the smallest operations thought they were better able to deal with low prices than were the larger sized operations. It has been suggested that the smaller operations may have lower variable costs and greater fixity in their farm assets and cost structure. The lower variable costs might be related to more of their feed being raised rather than purchased, and depreciated and paid off facilities and equipment. The lack of flexibility in their cost structure may make them more likely to "tough it out" under adverse economic conditions. The information in Table 18 is not adequate to test such hypotheses.

An analysis of hog farms in the Minnesota State College University System's (MnSCU) Farm Business Management Program provides some clues. The special analysis was performed by Dennis Jackson, Regional Dean of Management Education at Mankato. He analyzed the financial performance of 359 swine farms in 1998.

Hog prices were disastrously low in 1998. It is becoming more difficult to interpret quoted hog prices because of a shift to carcass-weight rather than live-weight pricing, quality differences, and marketing contract variations. The average of USDA weekly live weight prices for 47-49 percent lean hogs in 1998 was $31.93/hundredweight (Buhr). The price received by the MnSCU farms was higher, averaging $38.45/hundredweight for the year. This is still about 20 percent lower than what would be considered normal levels, and dipping to under $10/hundredweight by year end. Table 19 shows a summary for the 359 swine farms (all farms in the MnSCU database that raised at least one hog in 1998). The low prices resulted in pork producers averaging a net farm income of only $5,712 per farm. The farms generally operated crop enterprises as well as raising hogs, with half of their gross revenues coming from the swine enterprises on average. The first page of Table 19 shows the financial results for the overall farm operation, with results for the swine enterprises shown on the second page. Because the hog prices were so low and the swine enterprises generally did not cover costs, the farms with larger swine enterprises had lower net incomes than those with less involvement in swine.

The swine enterprises were of several different types. The most common types were the traditional farrow-to-finish enterprises (31% of the farms), or independent finishing enterprises (42% of the farms). Estimated return to labor and management per hundredweight of pork is shown only for the farrow-to-finish enterprises, in four size categories: under 1,000 market hogs produced/year, 1,000-2,500, 2,501-5,000, and over 5,000. The largest size breakpoint, 5,000 head, is still quite small compared to the larger size categories shown in Tables 7 and 18 above. While all sizes lost money in 1998, on a unit basis the loss was substantially less for the larger two size categories over 2,500 head ($5-6/cwt) than for the two smaller sizes ($10-15/cwt).

It must be kept in mind that the MnSCU farm business summaries do not include farms in the "mega" size categories that are gaining the greatest market share and are of great policy interest. The MnSCU farms sometimes organize their records into more than one type of swine enterprise, and the total number sold per operation was not calculated but rather the number sold for the individual operations. The second page of Table 19 shows the average number sold for the size categories. The eleven operations selling over 5,000 market hogs per year sold an average 8,514 per year. We do not have access to the individual farm data so we do not know how large the largest farms were in this group, but it is unlikely that any were in the largest size category from Table 7, 500,000 or more sold per year. Thus, it is likely that at least 24 percent of the U.S. hog slaughter is from operations larger than those represented in Table 19.

A comparison of the costs and returns across the size categories tells an interesting story. Both total expenses and feed costs, which are included in the total, are shown. Feed costs were very similar across the sizes, while total expenses/cwt increased with size which runs counter to the Lawrence and Purdue results. The cost difference may be due to facility investments and contract finishing arrangements that some of the larger operations may have undertaken. A comparison of the 5,000 plus and the 1,001-2,500 categories showed that the larger size had higher interest, depreciation, and lease expenses, which would be expected with new facilities. Custom hire expenses were also up, which could be related to arrangements with neighbors to finish extra pigs on an informal contract basis, and veterinary expenses.

The cost advantage of the smaller operations was overshadowed by the difference in prices received. On the revenue side, the average price received/cwt for raised hogs is shown along with gross revenue/cwt. Gross revenue/cwt is less because part of the pork produced is cull breeding animals which are worth less than the raised market hogs, and changes in inventory also enter into the gross revenue calculation. The larger operations received a higher average price than did the smaller operations ($41.21/cwt for those selling over 5,000 head compared to $32.69 for those selling less than 1,000).

There are at least four possible explanations for why the smaller operations received lower prices:

1) the smaller operations may have operated on more of a seasonal basis, and might have sold a larger share of their production at times of the year when prices were low,
2) there might have been carcass quality differences,
3) the some of the larger operations might have received price differentials related to quantity, such as marketing truck-load lots directly to packing plants rather than going through local buying stations, or
4) a higher proportion of the larger operations might have been marketing under long-term marketing contracts that paid more than the spot price.

Anecdotal information suggests that a fairly large proportion of Minnesota producers have entered into long-term marketing contracts with packers. A caveat - one common type of marketing contract is what is termed a "cash flow assistance" contract where the difference between the contract price paid to the producer and the (currently lower) spot market price is a loan to the producer which is expected to be paid back to the packer later when spot market prices recover. Accountants and lenders have been struggling with whether and how to include the amounts of those loans in producers' financial statements, because their status depends on what hog prices do in the future. Those loans were generally not included as liabilities in the

farm business summaries in 1998, so to that extent the financial results shown in Table 19 may be overstated especially for the larger swine enterprises, which tended to utilize marketing contracts more than the smaller ones.

Contract hog enterprises (mostly finishing, but also perhaps a few nurseries) were on 11% of the farms, with smaller numbers with farrowing or finishing enterprises that were split out at weaning age (around three weeks) rather than coming out of the nursery (7-10 weeks). Data is only shown for categories with at least ten farms.

An alternative view is to dismiss per unit production costs as a measure of economies of size, and to focus instead on where investment is occurring:

> "Because cost studies are inconsistent, the current cost of production may not be the best indicator of the future structure of the pork industry. In the final analysis, investment in facilities may actually provide a better indication of how commodity-side production will occur in the future than either cross-sectional or budgeted cost estimates. The part of the industry investing most heavily in production assets is likely to have the largest share of future production. The vast majority of the new investment in production facilities over the past four years has been made by nonintegrated and partially integrated production contractors. The unwillingness or inability of the independent producer sector to reinvest in production assets will (over time) reduce their position in the industry. This may be more a reflection of the absence of technologies within the financial reach of individual producers than a lack of interest or competence in hog production. But the net result will be to steadily shift a larger and larger percentage of production away from the small- and medium-size independent producers to production contractors and larger independent producers." (Boehlje and Schrader 1998)

The "survivor technique" is a statistical technique which is limited in its potential for detailed analysis, but is useful for providing an overview of broad trends. Originated in its modern form by (Stigler 1958), it has been applied to many manufacturing and food industries to some degree. It is based on the hypothesis that plant sizes which are efficient will survive and plant sizes that are inefficient will decline. The smallest group which shows an increase in its relative share is classes as the "minimum efficient size." A major problem is the fact that plants may survive for many reasons other than their internal efficiency (French 1977).

Table 19. Minnesota Swine Farm 1998 Financial Performance Summary

	<-Net Farm Income Profit Level->			<--No. of Market Animals Produced/Year-->			
	Average	Low 20%	High 20%	<1000	1,001-2,500	2,501-5,000	Over 5,000
Number of Swine Farms	359	72	72	130	100	49	31
Liquidity:							
Current Ratio (Ending)	1.38	1.02	1.77	1.51	1.36	1.62	1.22
Term Debt Cov. % (accrual)	54.0%	-41.0%	193.0%	78.0%	60.0%	39.0%	40.0%
Solvency:							
Farm Debt to Asset Ratio (ending, mkt)	55.0%	66.0%	43.0%	52.0%	52.0%	51.0%	61.0%
Profitability:							
Return on Assets %	1.1%	-9.1%	9.3%	2.2%	1.0%	0.1%	-0.3%
Return on Equity %	-8.2%	-49.7%	10.9%	-4.3%	-7.0%	-9.3%	-13.7%
Operating Profit Margin %	3.0%	-32.1%	22.6%	6.6%	3.0%	0.2%	-0.8%
Net Farm Income	$5,712	($89,604)	$108,604	$12,429	$11,430	($3,354)	($41,190)
Efficiency:							
Asset Turnover rate (cost)	35.8%	28.5%	41.0%	33.4%	35.0%	33.7%	33.6%
Operating Expense Ratio	82.8%	97.9%	71.0%	78.4%	82.5%	85.0%	89.1%
Depreciation Expense Ratio	7.7%	10.3%	6.2%	7.1%	7.0%	8.7%	7.5%
Interest Expense Ratio	8.1%	9.5%	5.8%	9.1%	7.2%	7.5%	7.2%
Net Farm Income Ratio	1.4%	-17.7%	17.0%	5.5%	3.3%	-1.3%	-3.7%
Family Income:							
Net Non Farm Income	$13,450	$15,318	$11,498	$14,614	$14,001	$13,080	$11,933
Total Family withdrawals	$45,248	$46,831	$69,801	$38,422	$44,635	$48,013	$60,197

	<--Net Farm Income Profit Level-->			<--No. of Market Animals Produced/Year-->			
	Average	Low 20%	High 20%	<1000	1,001-2,500	2,501-5,000	Over 5,000
All Hog Enterprises:							
Gross Income Hog Sales % (not including cull breeding stock)	47.6%	68.0%	36.4%	26.6%	43.2%	62.5%	76.2%
Farrow-to-finish enterprises only:							
Farms with farrow-finish enterprises, % of farms with hogs	31%			35%	41%	29%	35%
Farms with farrow-finish enterprises, no.	113	23	23	47	41	14	11
Average no. of farrow-finish sows	135	103	194	40	98	239	551
Average pigs sold/year	2,071	1,219	3,289	553	1,526	3,730	8,514
Average price/cwt for raised hogs	$ 38.45	$ 35.20	$ 40.14	$ 32.69	$ 35.92	$ 39.17	41.21

Table 19. (continued)

Returns and cost per cwt.:							
Gross revenue per cwt pork produced	$31.61	$25.28	$35.39	$ 23.39	$ 27.57	$ 33.94	$ 35.05
Feed cost per cwt	$22.68	$25.68	$20.38	$ 22.48	$ 22.16	$ 22.63	$ 23.08
Total expenses per cwt	$36.46	$41.87	$33.92	$ 34.29	$ 32.64	$ 37.10	$ 39.07
Net return	$ (4.85)	$ (16.59)	$ 1.47	$ (10.90)	$ (5.07)	$ (3.16)	$ (4.03)
Estimated labor hours	0.39	0.29	0.37	0.41	0.37	0.43	0.37
Labor & mgmt charge	$ 2.89	4.45	2.62	$ 4.18	$ 5.01	$ 2.67	$ 1.34
Est. return over labor & mgmt charge	($7.74)	($21.04)	($1.15)	$ (15.08)	$ (10.08)	$ (5.83)	$ (5.36)
Farms with feeder pig prod. enterprises	10%			10%	<10 farms	<10 farms	<10 farms
Average no. of feeder pig prod. sows	239			93			
Farms with finishing enterprises	42%			50%	46%	55%	39%
Average no. sold	2,121			621	1,691	3,353	9,764
Farms with contract hog enterprises	11%			<10 farms	<10 farms	<10 farms	<10 farms
Average no. pigs produced under contract	4,302						

	<--Net Farm Income Profit Level-->			<--No. of Market Animals Produced/Year-->			
	Average	Low 20%	High 20%	<1000	1,001-2,500	2,501-5,000	Over 5,000
Farms with farrow-wean enterprises	3%			<10 farms	<10 farms	<10 farms	<10 farms
Average no. of farrow-wean sows	302						
Farms with wean-finish enterprises	7%			7%	<10 farms	<10 farms	<10 farms
Average no. sold from wean-finish ent.	2,735			679			

Table 20 shows the number of farms selling hogs and pigs by size groups as reported in the last five Censuses of Agriculture between 1978 and 1997. The number of farms in the less than 1,000 head category has been declining over the entire period. The 1,000-1,999 size class shows how the minimum economic size has increased in the 1990's. The number of farms in this class increased until 1992, but has dropped since then. The 2,000-4,999 size class is still increasing in number of farms, but the bottom two lines of Table 20 show that they sold a smaller percentage of the hogs in 1997 than they did in 1992. The survivor technique would indicate that sales of at least 5,000 hogs and pigs per year are required today for economic viability. This is equivalent to around 250 sows at 20 pigs per sow per year. it should be noted that the Census of Agriculture defines farms on the basis of location rather than ownership. Pigs on "this place" that are being grown under production contracts are lumped together with pigs that are owned by the farm operator who controls or operates the place.

Table 20 is somewhat difficult to interpret because of the increasing segmentation in the swine industry. The swine industry was once made up mainly of operations that both farrowed and finished the hogs for slaughter. Today, the industry appears to be segmenting rapidly into operations that just farrow or just finish, and there are specialized nurseries and breeding stock multipliers which are all lumped together in Table 20.

Table 21 is a little easier to interpret because it shows just farms that farrowed sows. Here again, rapid change is evident. Only the last two censuses are shown. The size class farrowing 500-999 litters per year is equivalent to around 250-500 sows producing two litters per year. This class appears economically viable. The 200-499 litter class is increasing in percent of total farms, but decreasing in percent of total litters. The largest size class, 1,000 litters or around 500 sows, now produces half of the total number of litters.

Table 20. Numbers of Minnesota Farms Selling Hogs and Pigs by Size Groups, 1978-97

	Less than 1,000	1,000-1,999	2,000-4,999	5,000 or more	5,000-7,499	7,500 or more	Total
	Number of farms by head sold per farm						
1978	25,150	840	236	26	NA	NA	26,253
1982	19,840	1,483	436	44	NA	NA	21,802
1987	14,387	1,599	566	100	NA	NA	16,652
1992	9,158	2,378	2,031	182	107	75	13,749
1997	3,243	1,566	2,391	517	193	324	7,717
	Percent of total farms selling hogs and pigs						
1978	95.8	3.2	0.9	0.1	NA	NA	100.0
1982	91.0	6.8	2.0	0.2	NA	NA	100.0
1987	86.4	9.6	3.4	0.6	NA	NA	100.0
1992	66.6	17.3	14.8	1.3	0.8	0.5	100.0
1997	42.0	20.3	31.0	6.7	2.5	4.2	100.0
	Number of head sold per farm (000)						
1992	3,146	2,378	2,031	1,586	634	952	9,141
1997	1,483	1,566	2,391	7,503	1,150	6,353	12,943
	Percent of total hogs sold						
1992	34.4	26.0	22.2	17.4	6.9	10.4	100.0
1997	11.5	12.1	18.5	58.0	8.9	49.1	100.0

Source: Census of Agriculture

Table 21. Numbers of Minnesota Farms Farrowing Sows by Size Groups, 1978-97

	Less than 100	100-199	200-499	500-999	1,000 or more	Total farms
	Number of farms by number of litters farrowed per year					
1992	6,656	1,623	900	161	59	9,399
1997	2,937	769	602	188	196	4,692
	Percent of total farms farrowing sows					
1992	70.8	17.3	9.6	1.7	0.6	100.0
1997	62.6	16.4	12.8	4.0	4.2	100.0
	Number of litters farrowed					
1992	217	217	253	108	98	893
1997	93	107	175	132	522	1,029
	Percent of total litters					
1992	24.3	24.3	28.3	12.1	11.0	100.0
1997	9.0	10.4	17.0	12.8	50.7	100.0

Source: Census of Agriculture

Dairy Farm Profitability

Aging Facilities

Many of the dairy facilities on Midwest farms are old. They are still functional and productive and have limited alternative uses so they remain in use, but they do not lend themselves to the use of some new technologies so that limits the level of efficiency that can be attained. Parlor milking and free stall barns and bunker silos are in the minority. Table 22 shows the average year of construction and most recent improvements made on Minnesota and Wisconsin dairy facilities (Conlin 1995a).

Table 22. Construction date and date of last improvements in facilities on Midwest dairy farms

	Average year built		Average year remodeled	
	MN	WI	MN	WI
Housing	1963	1943	1976	1975
Milking	1964	1957	1978	1979
Feed storage	1969	1964	1978	1979
Feed handling	1973	1972	1980	1981
Waste disposal	1974	1974	1977	1981

North U.S. Dairy Survey, 1990.(Hammond 1989)

Diversification Versus Specialization

Diversification can be a risk-avoiding strategy. The idea is to spread the risk over several enterprises; low prices of one commodity will be offset by high prices in the other.

The typical Midwest diversified dairy farm produces feed for the dairy herd and relies on milk sales for 70 to 90 percent of its income. In reality, these farms are highly dependent on the price of milk. The diversified cropping enterprises only protect the farm from high feed prices. However, the cost of producing a bushel of corn, oats, wheat or barley is frequently more than the price for which it can be purchased. Production costs of feeds on dairy farms are often higher than on crop farms because of more limited scale efficiencies of the cropping enterprises.

Conlin discussed the diversification/specialization question in a proceeding paper based on a review of literature and farm financial records (Conlin 1995b). (See (Conlin 1998a) for a list of additional references.) Most of Midwest dairy farms produce a major portion of the feed for the dairy herd and are diversified in their capital investment, labor activities and management expertise required. Investment capital is almost always a limited resource.

The cropping activities require substantial investments in land and field machinery. Some over-investment occurred in the name of tax management during periods of investment tax credits and favorable profitability. Generally, diversified farms that raise their feed for small herds in stanchion barn systems have higher investments and higher labor inputs per cow.

Leasing of equipment and/or cows are options for reducing investments on the dairy farm. Some farmers use custom hire for some or all cropping activity. In most cases, the cost of leasing cattle exceeds the cost of ownership. It may be advantageous when leased cows will add to the return over feed and other cash costs, particularly if land and labor resources won't otherwise be fully utilized, and especially when the barn won't otherwise be full.

USDA researchers (El-Osta 1996) compared differences in the traditional milk producing states (MN, MI, WI, NY, VT, PA, NY, VT) with non-traditional milk producing states (FL, CA, WA, TX, AZ). They found significant differences in the resource base, and the structure of profitability and management practices between the traditional (68 cows) and non-traditional (370 cows) dairies. The factor found contributing most to net farm income regardless of location was size of the operation, but size was irrelevant in explaining per unit returns from dairy. High productivity and low debt to asset were strongly related to profitability. The importance of management ability to the profitability of the farm business is also noted in a five-state survey of the northeastern and north central region of the U.S. and Canada which found that well-managed farms are able to compete in per-unit profitability with farms many times larger (Ford and others 1996). This is consistent with overall conclusion by Hallam of an "L"-shaped cost curve which becomes flat at fairly low farm sizes, discussed under question E1.

El-Osta also found other factors contributing to higher levels of profitability in the traditional dairies were low investment costs in land and equipment, control of purchased feed cost, age of the operator, use of automatic takeoffs and artificial insemination, and level of adoption of capital- and management intensive technologies (record keeping combined with parlors). The authors point out that these dairies had a lower adoption rate (9%) of capital- management intensive technologies compared to non-traditional dairies.

Other factors in non-traditional dairies contributing to profitability included lower per cow expenditure for forage production, purchased feed, hired labor, and per cow investment. Per unit returns for dairies with advanced, more capital intensive parlors rather than traditional parlors

were lower. The study show there are incentives for these dairies to continue expansion, such as production and marketing economies, management expertise, tax incentives, specialization, labor saving equipment, timeliness of getting things done, non-farm investment, and farm consolidation. (El-Osta 1996)

Milk is a perishable product in a highly competitive national market and is highly sensitive to short range changes in the supply demand balance. The roller coaster ups and downs of milk prices have added a new dimension to management since the mid-1980's. This volatility has been very frustrating for many dairies while some have thrived on it. Federal government support price for milk is equivalent to $10.05 per cwt. in 1998, and scheduled to be lowered then discontinued on January 1, 2000. The support price is intended to serve as a price safety net. As the support price moved well below the average production cost, the market price has become highly volatile. This has led to some price stabilizing tools, futures and options markets, and milk processor contracts that set a price floor. Dairy lenders often encourage their use to stabilize income flows for meeting loan obligations.

Producers can control only 10 to 12% of the price they receive for their milk compared to their neighbors. Quality milk premiums can often make a dollar or more difference in the milk price. Milk is priced on a solids basis (protein, fat and other solids); therefore, high solids milk brings a better price per cwt. Producers need to balance quantity with percent milk component solids to maximize total returns. Some producers have found ways to negotiate additional premiums/benefits such as hauling charges, volume premiums, etc. (Conlin 1998b)

A 1992 survey of dairy farms in the northern part of the US and Canada provided a comprehensive comparative analysis of financial performance (Ford and others 1996). The study looked at the farm level performance of 2,200 dairy farms across four states, Michigan, New York, Pennsylvania, Wisconsin, and the providence of Ontario Canada. The data sets were pooled to provide a descriptive analysis of the financial characteristics of the dairy farm across the region. The results of this study are shown in Table 23, which summarizes financial performance of these farms by herd size. The average herd size was 84 cows and was summarized in six categories ranging from less those 30 cows to over 250 cows.

The authors concluded that what stood out in their analysis is farms within herd size categories have more performance factors in common with other farms in other states than they do with farms of different herd sizes in the same state. Ontario is an exception due to larger investments and higher debt per cow under the Ontario milk marketing system. The authors provided descriptions of these differences.

Profitability

Net farm income, with or without appreciation, is more than 10 times larger on the largest farms than on the smallest farms. Labor and management income per operator/manager ranged from minus $6862 on the smallest farms to over $90,000 on the largest farms. Full time operator/management units were based on 2800 hours per year and excluded hired labor and unpaid family labor. Rate of return on equity capital with appreciation was negative for smaller farms, but almost 9 percent on the largest farms. Rate of return on all capital with appreciation shows a similar pattern but with a smaller range.

Productivity

The larger herds sold 20% more milk per cow, 19191 lbs. for herds averaging 439 cows compared to 15999 lbs. for herds averaging 32 cows. Pounds of milk per worker ranged from 391,349 lbs. annually for the small herd group to 881,000 for herds over 250 cows. It took one worker per for 26 cows in the small herds compared to 46 cows in the larger herds.

Cost Control

Grain and concentrate purchased as a percent of milk sales, and feed and crop expense per cwt. of milk sold generally increased, but by only a small amount, as herd size increased. Labor and machinery costs per cow decreased as herd size increased. Operating costs of producing milk increased with herd size because a greater portion of the labor is a cash cost, where as most labor on small farms in provided by the operator and family.

Capital Efficiency

Farm capital per cow decreased dramatically as herd size increased. Farm capital per cow was one-third less for the largest farms compared to the smallest farms. A similar pattern existed for machinery and equipment investment per cow. Asset turnover rates increased as herd size increased indicating that each dollar invested is being used more productively on larger farms.

Table 23. Characteristics and Financial Performance of Pooled Data Set, All farms and by Herd Size, 1992

	Mean Values by Herd Size						
	All Farms	10-39 cows	40-79 cows	80-119 cows	120-159 cows	160-249 cows	250 and over
SIZE OF BUSINESS							
Average number of cows	84	32	57	95	136	193	429
Milk sold, LB	1,502,715	519,390	969,236	1,702,880	2,535,201	3,558,784	8,274,866
Worker equivalent	2.49	1.49	1.89	2.72	3.70	4.79	9.67
Total tillable acres	263	129	190	303	434	565	972
RATES OF PRODUCTION							
Milk sold per cow, LB	17,348	15,999	17,058	17,999	18,582	18,450	19,191
Hay DM per acre, tons	2.84	2.32	2.76	3.05	3.19	3.26	3.46
Corn silage per acre, tons	15.74	14.25	15.82	16.23	15.80	15.64	16.97
LABOR EFFICIENCY							
Cows per worker	34	25	33	38	42	44	46
Milk sold per worker, LB	595,572	391,349	555,126	678,577	768,247	795,944	881,696
COST CONTROL							
Grain & conc. Purr. - % milk sales (%)	26	26	25	26	26	26	28
Feed & crop expense/cwt ($)	4.48	4.37	4.41	4.66	4.69	4.60	4.68
Labor & mach. Costs per cow ($)	849	1,074	834	789	810	771	772
Oper. cost of prod. milk ($)	10.04	10.01	9.82	10.32	10.39	10.51	10.52
CAPITAL EFFICIENCY (YEAR AVG.)							
Farm capital per cow ($)	7,798	8,819	8,053	7,368	6,879	6,525	6,108
Machinery & equip. per cow ($)	1,363	1,572	1,391	1,347	1,229	1,062	960
Asset turnover ratio	0.40	0.36	0.38	0.43	0.46	0.49	0.56
PROFITABILITY							
Net farm income w/o apprec. ($)	33,047	11,396	22,510	35,342	54,694	68,570	195,022
Net farm income w/ apprec. ($)	54,555	20,065	37,947	59,991	87,200	116,489	291,951
Labor & mgmt. Income per oper./ mgr. ($)	2,551	-6,862	-861	3,769	3,890	13,118	90,377
Rate of return on equip. cap. w/ apprec. (%)	-1.30	-8.63	-2.01	-0.09	3.89	6.05	8.89
Rate of return on all cap. w/ apprec. (%)	1.96	-2.66	1.39	3.78	4.71	5.24	7.96
FINANCIAL SUMMARY							
Farm net worth, end year ($)	443,355	213,198	336,625	495,188	713,151	857,061	1,676.021
Debt to asset ratio	0.30	0.26	0.29	0.32	0.28	0.39	0.39
Farm debt per cow ($)	2,143	2,098	2,139	2,264	1,818	2,330	2,216

SOURCE: *A Descriptive Analysis of the Characteristics and Financial Performance of Dairy Farms in Michigan, New York, Ontario, Pennsylvania and Wisconsin.* Dept. of Ag., Res., and Managerial Econ., Col. of Ag. and Life Sci., Cornell Univ., Ithaca, NY. R.B. 96-08, July 1996.

Financial Summary

Farm net worth ranged from $213,198 on the smallest farms to over $1,675,000 on the largest farms. Debt to asset ratio increased, while farm debt per cow remains relatively constant moving from smallest to largest herd sizes.

The authors noted that the farms in the sample data were a bit larger and higher producing except in Pennsylvania herds when compared to the most recent census data averages.

There are several sources of dairy farm financial data from other states, (Wisconsin, Michigan, Pennsylvania, and New York) that is reported as aggregated averages for author defined classifications. Each has it's own set of characteristics that may limit direct comparison with the data from Minnesota without technical interpretation. Therefore these have not been included in the dairy farm financial performance information reported here.

The Minnesota Farm Business Management Program conducted administered by the Minnesota State Colleges and Universities provides an annual aggregated summary of farm records from across the state. This is the largest farm financial data source in the state. It is very useful, but comes with certain restrictions to protect the privacy of the participating farms. The data is made available only in summary form, with no access to individual farm data. These restrictions make it somewhat difficult to assess how similar the summarized farms are to the entire Minnesota dairy farm population, and do not allow cross-year analysis or factor analysis which might explain in more detail what factors affect profitability. Group aggregated summaries provided by the program are based on dairy farms with more than 70% of gross farm income from dairy. Summaries of this data are shown for two separate years. The 1996 summary below (Tables 24 through 26) provides a high level of detail in order to characterize Minnesota dairy farms. Table 27 includes only selected measures but is included to indicate how economic conditions had changed by1998. This data source is not necessarily representative of all Minnesota dairy farms relative to size, productivity, enterprise mix, and other management factors.

Summaries of Minnesota Farm Business Management records for dairy farms show large farm-to-farm differences in the economic and production performance of producing milk (Jackson 1999). They also show large swings in profitability from year to year. The 1996 comparison of high and low profit Minnesota dairies (Tables 23 through 25) reveals some important differences comparing the 20% high profit dairies with the 20% low profit group. Similar data for 1998 are shown later in Table 27. The profit groups are based on net farm income. This summary is based on more than 800 Minnesota dairy farms in 1996 from the Farm Management Education Program, Minnesota State Colleges and Universities. Conlin has compiled a summary analysis of these records from 804 Minnesota dairy farms and interpreted the results. Some of the compiled summaries reflect subsets of the 804-farm sample because useable data was not available for some farms. Key differences in the overall profit performance of these farms are as follows: (Conlin 1998b)

Profitability: Return on assets was 11.9% for high profit dairy farms while the low profit group had a return of .4%. This resulted in a higher net return of $3.43 compared to $-2.10 per cwt of milk. The high profit dairy farms had an Operating Profit Margin of 30.5% compared to 1.4% for the low 20% profit group. The net worth growth from 1995 to 1996 was $-4,331 compared to $78,002 for the low and high profit groups.

Family Living and Unpaid Labor: The high profit group enjoyed an advantage of $7,299 more family living and non-farm investment. The average labor management charge per cwt milk for the high profit group was $.95 compared to $1.48 for the low profit group. The low profit group had $16,573 of non-farm income compared to $7,246 for the high profit group.

Table 24. Income, Costs and Returns, Minnesota Dairy Farms, 1996

	Low 20%	Average	High 20%
No. of farms	161	804	161
Herd size (cows)	54	64	73
Production per cow, lb.	14,639	17,428	19,812
Income			
Milk price	$ 14.56	$ 14.81	$ 14.99
Sale culls/calves/other	1.03	0.87	0.86
Inventory changes	(0.07)	0.39	0.73
Gross income per cwt	15.52	16.07	16.58
Expenses			
Herd replacements	$2.71	$ 2.28	$ 2.08
Feed cost	7.88	6.54	5.66
Other variable cost	3.10	2.50	2.17
Overhead cost	2.45	2.28	2.29
Labor mgmt charge	1.48	1.11	0.95
Total Cost	$ 17.62	$ 14.71	$ 13.15
Net Return to Capital	$ (2.10)	$ 1.36	$ 3.43
Dairy enterprise return to capital	$ (16,601)	$ 15,169	$49,607
Percent income from dairy	77%	75%	68%
Net Farm Income	$ (8,105)	$ 38,502	$ 102,608

Table 25. Minnesota Dairy Farm Balance Sheet, 1996

	Low	Average	High
Farm Assets			
No. of farms	147	705	104
Current	$47,630	$65,857	$135,567
Intermediate	177,631	297,944	327,076
Long term	202,282	217,283	319,909
Total Assets	430,543	491,084	782,555
Farm Liabilities			
Current	51,115	42,271	63,719
Intermediate	82,848	72,077	96,892
Long term	107,269	100,061	123,163
Total Liabilities	241,332	214,409	283,774
Net Worth	219,710	315,903	571,836
Net Worth Change, 1995-96	-4,331	23,623	78,002

Source: Farm Business Management Report 1996, Minnesota State Colleges and Universities (Anonymous undated).

Table 26. Business Performance Measures, 1996

	Low Profit	Average	High Profit
Profitability			
Return on farm assets	0.4	7.4	11.9
Labor & management earnings	-12,051	26,666	76,243
Operating profit margin	1.40%	22.10%	30.50%
Liquidity			
Current ratio	0.93	1.7	2.51
Working capital	-3,766	32,759	82,903
Solvency			
Farm debt to asset ratio	57%	44%	34%
Farm equity to asset ratio	43%	56%	66%
Repayment Capacity			
Term debt coverage ratio	46%	140%	224%
Capital replacement margin	-16,187	11,321	109,142
Efficiency			
Years to turn over assets	3.8	3	2.6
Operating expense ratio	82.50%	69.70%	65.90%
Depreciation expense ratio	10.30%	6.00%	3.70%
Interest expense ratio	11.80%	7.50%	5.20%
Net farm income ratio	-4.50%	16.80%	25.20%
Dairy Farm Characteristics			
Crop acres	284	329	537
Percent income from dairy	77	76	68
Acres per cow	5.26	5.14	7.36
Assets per cow	7,973	7,673	10,710
Assets per cwt milk produced	55	44	54
Debt per cwt milk produced	31	19	20
Assets per acre	1,516	1,493	1,457
No. of sole proprietors	59	309	48
Average family size	3.0	3.7	4.9
Total family living expense investments & non-farm purchases	25,538	26,851	33,837
No. of farms	165	826	165
Average no. of operators	1.1	1.2	1.7
Average age of operators	42	42	40
Non-farm income	16,573	9,960	7,246

Dairy Farms Compared to All Farms

	Dairy	All Farms
Machinery/equipment assets per acre	344	237
Corn yield, bu per acre	113	125
Corn silage tons per acre	14	15
Alfalfa, tons per acre	3.2	2.8
Soybeans, bu per acre	37	38
Land rent per acre	56	72

Price Income Performance: High profit dairies had an income advantage of $1.06 per cwt of milk marketed. The gross income from all of these sources ranged from $15.52 for the 20% low profit dairies to $16.58 for the high profit group among 800 Minnesota dairy farms in 1996 (Table 24). High profit dairies received almost $0.43 more per cwt for their milk largely due to premiums for quality and other. Sales of cows and calves and animal inventory changes added $0.63 per cwt to the advantage of the high profit group. Sale of cull cows, dairy animal sales, growth in herd inventory from year to year, and credit for milk fed to calves or used by the family can typically be equivalent to $1.25 to $1.50 per cwt. About 40% of the difference in gross income per cwt was due to milk price; the rest was due to non-milk income sources.

Profit Centers for Income per cwt: High Profit dairies have higher gross income per cwt of milk marketed. They receive a higher milk price because of premiums for quality, etc. Greater income from animal sales and changes in inventory are important contributors to a higher gross income per cwt.

Variable Costs: High profit dairies had a lower operating expense ratio, spending $0.66 to generate $1.00 of income compared to $0.83 for the low profit group. Total cash cost of production was $13.15 compared to $17.62 per cwt. for the low profit group. High profit dairies had lower feed costs by $2.22 per cwt. ($5.66 Vs $7.88) for milking cows, lower other variable costs ($2.17 Vs $3.10), breeding fees, health care, supplies, repairs, etc. Herd replacement costs were $2.08 Vs $2.71 per cwt. of milk in favor of the high profit group (Tables 23 and 25).

Capital Costs: High profit dairies had a lower debt asset ratio (34% Vs 57%) but higher total assets and liabilities. The high profit group had higher investment per cow and about equal investment per cwt. of milk. Debt per cwt. of milk was $20 Vs $31 to the advantage of the high profit group. High profit dairies had lower overhead costs ($2.29 Vs $2.45), they also had a substantial advantage in the depreciation and interest expense ratios and years to turn over assets. The typical $7,500 to $10,000 investment per cow for the income generated is a major profit constraint on many Midwest dairy farms. Machinery and equipment investment on dairy farms was $344 per crop acre compared to $237 on all farms (Tables 23 and 25).

Production Performance: High profit dairies marketed about 5,200 more LB of milk per cow and had larger herds (73 Vs 54 cows per herd). Minnesota studies showed that with good cost control and balanced management, returns to labor and management increased by $0.30 to $0.50 per cwt. of milk for each additional 1,000 LB of milk produced per cow. Milk and feed prices will affect this return. Dairy farms when compared to all farms had crop performance per acre yields: corn grain, 113 Vs 125 Bu; soybeans, 37 Vs 38 Bu; corn silage, 14 Vs 15 ton; alfalfa 3.2 Vs 2.8 tons. Land rent paid was $56 per acre for dairy farms compared to $72 for all farms (Table 26).

The summary shown in Table 26 was developed by the authors to reflect more current Minnesota dairy farm economic information than the 1996 summary data above which has more detail. This summary is consistent with previously referenced studies on dairy profitability from other states and previous years. Higher levels of profitability are an evident reflection of relatively high milk prices and relatively low feed prices enjoyed in 1998. Milk produced per cow also increased. Feed expense per cow increased even though grain prices were relatively low in 1998,

suggesting that producers may have adjusted their feeding programs, which might partially explain the milk production increase. The are large differences in the performance and key characteristics between high and low profit herds. Larger herds tended to be more profitable except for the group with over 300 cows. It is apparent that this largest group may not include several of the state's largest dairies. Several dairies with over 500 cows that have been recently been developed in the state, with a few having over 1,000 cows. These large dairies typically use private proprietary services for their accounting rather than participating in the public-sector farm business summary programs. It is evident from this summary that productivity, cost control, capital efficiency, and herd size are factors affecting the financial performance of dairy farms. The higher depreciation and interest expense ratio suggest the herds in the two largest categories are in a period of expansion which typically increases production costs until the expanded operations have stabilized. It is noted that non-farm income appears to be inversely related to net farm income.

The survivor technique applied to Tables 13 and 14 indicates that the minimum sized dairy operation required to be economically viable is at least 50 cows, because numbers in the size classes less than 50 are clearly declining. One could argue that at least 100 cows are required for economic viability, because only the 100-199 and the 200+ classes are increasing in percentage terms (see the bottom panels of the two tables).

The number of milk cows in Minnesota and the number of dairy farms by herd size are shown in Tables 13 and 14. The actual numbers as reported by the USDA National Agricultural Statistics Service are shown for 1993 through 1998. Hammond used a Markov chain technique to project the trend out to the year 2004, based on the assumption that the probability of increasing or decreasing numbers in each size group is the same as observed for the changes from 1996 to 1997. This also implies that the factors causing the changes: milk prices, demands for milk products, adoption of improved milk production technologies and other determinants of changes in industry structure will, on average, continue to impact as they did for 1996-97. The 1997 data was the latest available when Hammond did the projections. The actual 1998 data has since been added as a way of gauging the accuracy of the earlier projections. The rate of structural change appears to have slowed down in 1998 compared to 1997. Milk prices were lower in 1997 (Minnesota average $13.16 per hundredweight all milk price) than in 1996 ($14.60 average), but then were generally higher throughout 1998. the Minnesota price peaked out at $18.99 in December before retreating to $13.40 in March 1999 (Anonymous various issues). The more favorable milk prices in 1998 may have resulted in less economic pressure to either exit the industry or to maintain family income by expanding, two actions which would have been reflected in this data. The drop in milk prices in 1999 may force more rapid change like that seen in 1997.

Table 27. Minnesota Dairy Farm 1998 Financial Performance Summary

	<----Net Farm Income Profit Level---->			<---------- Herd Size (number of cows) ---------->			
	Average	Low 20%	High 20%	<100	100-200	200-300	300 +
Number of Dairy Farms	678	136	136	565	81	18	11
Liquidity:							
Current Ratio (Ending)	1.71	0.96	2.14	1.78	1.9	1.02	1.29
Term Debt Cov. % (accrual)	175	86	266	160	198	184	195
Solvency:							
Farm Debt to Asset Ratio	49	63	45	47	51	64	62
Profitability:							
Return on Assets %	10.4	0.2	15.4	9.4	12.8	12.5	11.3
Return on Equity %	13.5	-18.9	22.7	11.5	18.1	21.7	17.5
Operating Profit Margin %	24	0.6	31.4	23.1	26.7	27.2	22
Net Farm Income	$ 56,966	$ (588)	$ 145,640	$ 45,561	$ 102,480	$ 140,963	$ 167,256
Efficiency:							
Asset Turn Over rate (cost)	43.1	35.7	48.9	40.8	48	46.1	51.4
Operating Expense Ratio	66	77.1	63.3	64.7	67.1	68	70.9
Depreciation Expense Ratio	6.5	12.2	5.1	6.2	5.4	7.3	10.1
Interest Expense Ratio	7.5	11.2	5.8	7.6	6.7	8.7	6.9
Net Farm Income Ratio	20.1	-0.4	25.7	21.6	20.8	15.9	12
Family Income:							
Non Farm Income	$ 12,038	$ 18,368	$ 9,184	$ 10,871	$ 6,880	$ 8,207	$ 9,655
Total Family withdrawals	$ 36,346	$ 33,614	$ 44,429	$ 36,017	$ 41,285	$ 36,177	$ 55,697
Dairy Enterprise:							
Gross Income Milk Sales %	75	76.2	76.3	68.1	83.8	89.1	91.5
Av. Herd size (No Cows)	69.9	60.2	87.2	53	132.8	250.5	376.1
Milk lbs. per cow	18,506	15,353	21,276	17,699	19,667	19,427	21,284
Returns and Cost Per cwt.: Including Replacement Animals							
Gross Rev per cwt Milk	$ 16.44	$ 15.25	$ 17.17	$ 16.61	$ 16.35	$ 15.35	NA
Expenses per cwt milk	$ 12.68	$ 14.62	$ 11.72	$ 12.62	$ 12.66	$ 13.00	NA
Feed cost per cwt milk	$ 6.89	$ 8.16	$ 6.10	$ 7.11	$ 6.81	$ 6.28	NA
Est. Net Ret/Labor&Manage.	$ 2.56	$(0.80)	$ 4.41	$ 2.56	$ 2.72	$ 1.70	NA

Source: Adapted from special reports prepared by Dennis Jackson, MNSCU, Mankato from the Minnesota (MNSCU) 1998 Statewide Farm Business Management Summary database

Table 28. Number of Milk Cows on Minnesota Farms by Herd Size, 1993 to 1997 with Projections to 2004

		Cows (000) by Herd Size Category:					
	Year	1-29	30-49	50-99	100-199	200+	Total Cows
Actual	1993	60	206	263	89	17	635
	1994	54	189	256	91	19	609
	1995	47	168	257	96	31	599
	1996	42	155	245	102	54	598
	1997	35	134	239	99	76	583
	1998	32	120	218	87	88	545
Projected	1998	29	116	231	97	97	570
	1999	24	100	223	94	118	559
	2000	20	86	214	91	138	549
	2001	17	74	204	89	158	542
	2002	14	64	194	86	177	535
	2003	12	55	184	83	196	530
	2004	10	48	175	79	214	526
Av. herd size for group, 1997		21	37	66	117	303	58
Annual % change 1993-97		-12.5	-10.2	-2.4	2.8	45	-2.1
% change 1996-97		-16.4	-13.8	-2.5	-2.5	40.8	-2.5
% change 1997-98		-9.7	-10.5	-8.8	-11.9	16.2	-6.5

Percent of state's cows in herds with cow numbers of:							
		1-29	30-49	50-99	100-199	200+	Total
Actual	1993	9%	32%	41%	14%	3%	100%
	1994	9%	31%	42%	15%	3%	100%
	1995	8%	28%	43%	16%	5%	100%
	1996	7%	26%	41%	17%	9%	100%
	1997	6%	23%	41%	17%	13%	100%
	1998	6%	22%	40%	16%	16%	100%
Projected	2004	2%	9%	33%	15%	41%	100%

Source: Actual data is from USDA National Agricultural Statistics Service, "Milk Production." Projections are from Hammond, Jerome W., The Changing Structure of Minnesota's Milk Production Sector," Department of Applied Economics, University of Minnesota, presented at the Annual Conference of the International Association of Milk Control Agencies, Airport Hilton Hotel, Bloomington, Minnesota, August 16-18, 1998.

Table 29. Number of Minnesota Dairy Farms by Herd Size, 1993 to 1997 with Projections to 2004

		Herd Size Category:					
	Year	1-29	30-49	50-99	100-199	200+	Total Cows
Actual	1993	3,300	5,400	4,000	730	70	13,500
	1994	2,900	4,700	4,100	720	80	12,500
	1995	2,600	4,500	4,100	780	120	12,100
	1996	2,100	4,100	3,800	830	170	11,000
	1997	1,700	3,600	3,600	850	250	10,000
	1998	1,600	3,500	3,500	800	300	9,700
Projected	1998	1,376	3,161	3,411	880	334	9,162
	1999	1,114	2,775	3,231	901	421	8,442
	2000	902	2,437	3,061	914	510	7,824
	2001	730	2,140	2,900	920	600	7,290
	2002	591	1,879	2,747	921	691	6,829
	2003	478	1,650	2,603	917	782	6,430
	2004	387	1,449	2,466	908	872	6,082
Annual % change							
1993-97		-15.3	-9.6	-2.6	3.9	37.5	-7.2
% change 1996-97		-19.1	-12.2	-5.3	2.4	47.1	-9.1
% change 1997-98		-5.9	-2.8	-2.8	-5.9	20.0	-3.0

Percent of state's dairy farms with herds with cow numbers of:							
		1-29	30-49	50-99	100-199	200+	Total
Actual	1993	24%	40%	30%	5%	1%	100%
	1994	23%	38%	33%	6%	1%	100%
	1995	21%	37%	34%	6%	1%	100%
	1996	19%	37%	35%	8%	2%	100%
	1997	17%	36%	36%	9%	3%	100%
	1998	16%	36%	36%	8%	3%	100%
Projected	2004	6%	24%	41%	15%	14%	100%

One final comment on the study questions is that the introduction to topic E mentions economies of scale and government policies, but does not explicitly ask the question of how government polices, and especially federal commodity programs, may influence economies of scale or have a "large farm bias." There is an extensive body of literature on this topic, and we will not address it in depth but rather just mention that the issue exists. The question is focused mainly on the major crops and to some extent dairy, rather than on other livestock and poultry, because the commodity programs do not directly cover other livestock and poultry. One book that focused on the debate leading up to the 1996 farm bill was (Cochrane and Runge 1992), but there are many other publications as well.

Question E2. How is the profitability and economic viability of farms and firms affected by different production and marketing arrangements? What are the comparative internal economic costs and benefits of various livestock production systems?

Question E2a. How is the profitability and economic viability of farms and firms affected by different production and marketing arrangements?

An overview of farmers' use of marketing and production contracts as provided in the 1993 USDA Farm Costs and Returns Survey is provided in (Anonymous 1997c). Figures on the percentage of pork producers utilizing various types of production and marketing contracts in 1997, and perceived contract advantages and disadvantages are available in (Lawrence and others undated). An update on marketing contracts is available in (Anonymous 1999).

There are obviously many different production and marketing arrangements in use in livestock production. In responding to this question with respect to an individual livestock operation, it is necessary to make assumptions about the rest of the industry. A bit of Economics 101 - Generally speaking, at any point in time in any industry made up of more than one firm, the different firms operate at different levels of efficiency, profitability, and risk. They compete, and over time the more profitable firms expand and drive down prices while the less profitable firms shrink or gradually leave the industry. This scenario assumes that all firms produce an identical, generic commodity.

The impact of different production and marketing arrangements on the profitability and economic viability of a particular, representative farm will depend on how broad the adoption of the arrangement is in the rest of the industry. Increasingly, it is becoming more feasible to produce agricultural products with specific characteristics which may bring different prices when marketed though "niche" marketing channels. Over time, livestock operations, like other businesses, tend to adopt the most promising new arrangements. The "treadmill hypothesis" states that the early adopters reap higher profits for awhile when they adopt, but when the rest of the industry adopts then profits return to normal levels. Any particular production or marketing arrangement aimed at a niche market may provide high returns to the first few farms that get into it, but the market may become saturated quickly so that later adopters may suffer losses under the same arrangement (Cochrane 1979), pp. 389-390.

Changes in hog procurement practices are causing a number of problems for farmers who continue to rely on the spot market. Some of these problems were identified by 28 hog farmers in Minnesota, Iowa and South Dakota who were interviewed in 1997. The main problems identified were ((Land Stewardship Project 1999)):

- delays of several days until packers can accept delivery of animals, rather than the previous situation where farmers could call and deliver their hogs the same day,
- closing of local buying stations, requiring greater travel distances,
- perceived price reductions relative to what large producers were receiving (it is not clear what information about large producers' prices they were using to make this comparison, or how accurate their information was), and
- missing out on quantity premiums or other "special deals" that large producers were receiving.

Much of the debate about the fairness of long-term hog marketing contracts revolves around whether quantity premiums paid to producers under long-term marketing contracts or for larger spot market lot sizes are unreasonable compared to what is paid for smaller spot sales (see, for example section V of Land Stewardship Project). "Reasonableness" relates to how such premiums compare to differences in packers' procurement and operating costs. Two relationships that have not been quantified very well in past research include: 1) how packers' hog procurement costs vary with lot size (number of animals involved in the individual transaction), and 2) how much slaughter plant per unit operating cost increases when the plant is operated below or above optimum rates on any given day. This may be an area that can only be effectively researched using data obtained under the auspices of the USDA Packers and Stockyards Administration's or other government agency's subpoena power.

The increased use of contracts together with more concentrated ownership of germplasm has raised concerns of a possible shift in bargaining power away from producers and their receiving a smaller share of revenue from production (Harl undated). The changes and driving forces are well laid out in this paper, although as discussed in the introduction, like any predictions it is up to readers to judge the likelihood of their coming to pass.

Swine Farm Profitability

The more major agricultural commodities also go through production and price cycles, but over a longer time period. Hogs, for example, tend to follow a cycle of about four years. An arrangement that appears profitable when prices are at a high point in the cycle may not look nearly as profitable at the low point.

Less efficient arrangements may have negative impacts on profitability in an economic environment where more efficient arrangements are competing. The same, less efficient arrangements may provide adequate profits in a different economic environment where the more efficient arrangements are restricted by government policies, provided that the policies are adopted over a large enough geographic area that competing products cannot be imported. This restriction scenario does not specify what the rationale might be for such restrictions. The restrictions could be instituted on economic, environmental, animal welfare, or other grounds.

Marketing arrangements generally address two goals: enhancing the expected price, and reducing risk. The major types of livestock marketing arrangements include the traditional daily spot markets, futures and options trading though the established futures markets, and marketing contracts with processors that may extend for periods of a few months up to five years or more. In the case of pork, marketing contracts may be fixed price, fixed basis, formula price, cost plus, price window, and price floor. The price established under the contract may be a final price, or the contract may be of a cash flow assistance nature in which case the final price may be based on the spot market price with the difference between the spot price and the contract price being a loan balance kept in a ledger account (Buhr Undated). Direct marketing to local consumers is another arrangement that is being utilized by some producers.

We assume that we are mainly interested in how different production and marketing arrangements might affect profitability in the future, rather than just in the past. Prices fluctuate daily. Any comparison of marketing arrangements must take into consideration this price

variability. Buhr compared three types of hog marketing contracts and found that when averaged out over three years, the contract price averaged from 98 to 104% of the spot market price (Buhr Undated). Simply comparing the prices that a representative farm would have receive on any given day, or even in any one year in the past, under different marketing arrangements will not necessarily predict how the arrangements will perform in the future.

One way to address the price variability issue is to look at processing costs. At least two assumptions must be made: 1) the retail price is constant, and 2) packers will compete and pass any processing cost savings on to farmers. If we accept these two assumptions, then the implication is that a marketing arrangement that reduces processing costs will improve farm profitability compared with a marketing arrangement that involves higher processing costs. Over the long run, however, assumption (1) that the retail price is constant, is probably not valid. Over the long run, economic theory suggests that any arrangement that increases farm profits above normal levels will result in expansion and a farm-level supply increase. In order to sell the increased production to consumers, it will probably be necessary for prices to decline which will return profits to normal levels. The validity of assumption (2) depends on the relative elasticities of demand at the farm-packer and packer-retailer levels.

Martinez and others used a simulation model to estimate the changes in hog prices that would result from a packer purchasing hogs under various levels of marketing contracts or integration which specify genetics and market weight, compared to buying on the spot market (Martinez and others 1998). Also see (Martinez 1997) and (Martinez 1998). They estimated shifts in retail demand related to increased leanness, shifts in retail supply related to increased leanness, and hog acquisition costs. They assumed a packer savings of $6.32/head by slaughtering a hog that is 19% leaner than average, for a potential marketing cost savings of 2.86%. They assumed that contracting or integration would reduce hog purchasing costs by $0.48/head. They also assumed that consumers would be willing to pay 4.3% more for pork that is 10% leaner. They look at several scenarios of 11%, 29% and 100% contracting or integration, and with or without consumer demand changes. They find that in the short run (one year), hog prices would increase from 0.2 to 2.0 percent at 29% contracting or integration. After more than five years, however, hog prices would return to normal while hog production would increase by 0.2 to 1.7% at 29% contracting or integration. Higher or lower levels of contracting or integration would result in larger or smaller impacts.

The annual reports of the Minnesota State College University (MnSCU) Farm Business Management Program and the Southwestern Minnesota farm Business Management Association do provide some evidence of how returns from contract production of hogs compare with non-contract hog finishing (Anonymous undated), (Olson and others 1999). The 1994 through 1997 years were profitable ones for independent hog finishing operations, while 1998 was not (Table 30). Prices for market hogs averaged $46.38 per hundredweight over the five years, with net returns averaging $2.92 per pig produced. The share of total farm labor disappearance allocated to the swine enterprises and the returns per head calculate to hourly earnings averaging $6.56/hour over the five years. In 1998, hog prices only averaged $38.86/hundredweight. The 163 independent finishers lost an average $14.13/head, or $33.75 per hour worked.

Forty one contractee producers earned $4.78/pig space on average in 1997. The figures on pigs produced per pig space are probably not very accurate for the contract producers, since the

stocking density in the buildings is often under control of the contractor who may not provide this data to the contractee producer. If the reported pigs produced per pig space is accurate, then the contractee producers earned an average of $1.57 per pig in 1997 and 1998. This is less per pig than the independents earned on average over the five years, but at least the contractees did not incur the large losses that the independents experienced in 1998. The classification of a particular farm's hog enterprise as a "contractee" one is up to the farmer and instructor, but in general these are enterprises where the farmer does not own the animals but owns the facility and supplies the labor.

The contractees' earnings worked out to $9.35/hour in 1997 based on an estimated share of total farm labor allocated to the enterprise. The contractees' hourly earnings declined slightly in 1998, to $8.06/hour. Contract production seems to be offering lower risk than independent finishing, judging by the fact that the contract producers' hourly earnings only declined 15 percent in 1998 while the independents incurred large losses. It remains to be seen how the hourly earnings of the contract producers average out over the longer term compared to the independents.

It should be noted that the enterprise summaries include interest on debt, but not an opportunity cost interest charge on equity capital invested in the enterprise, so the hourly earnings shown here are what remained as a return to the operators' equity capital as well as labor and management. The summaries include tax depreciation rather than debt principal payments which are more of a cash flow measure, so operations that are paying off debt more rapidly than they are being depreciated may not realize cash earnings after debt payments that are as high as those shown. On the other hand, the facilities will probably have some residual asset value after the debt is paid off and the contract terminated which is not included in these earnings estimates.

It should also be noted that the above contract vs. independent comparison is only based on two years of data. Results may be much different in future years depending on how the market situation evolves.

The data also indicates better labor efficiency in the contractee enterprises than in the independent finishers (in 1998, 0.17 hours/pig produced compared to 0.42). The database does not include any data on facility age, but it is likely that this is mainly due to the contractee enterprises having newer facilities on average. We base that conclusion on statements made in recent years that production contracts have made it easier to obtain facility financing.

This comparison illustrates the risks that independent finishers face in terms of market volatility, which in a production contract situation is usually experienced by the contractor rather than the contractee. It is fairly well documented that in most business enterprises, entrepreneurs demand higher expected returns as a tradeoff for accepting higher risks. Contractee hog producers generally provide a facility (a capital investment) and labor. They generally shift many management decisions to the contractor, along with much of the risk. It would be expected that contractees will earn lower returns per unit over time in return for avoiding these risks.

It is also fairly well documented that contractee producers do not avoid all risks. For example, Production contracts often include performance incentives or bonus plans that shift at least some production risks such as death losses or poor feed conversion to the contractee, and there is also what is sometimes referred to as "relationship risk" that the contractor will go bankrupt or

otherwise default on their contractual obligations. One source on the risks and benefits of hog production contracting with additional details on typical contract provisions is (Dotson 1996).

Another business arrangement that seems to be gaining popularity in the Minnesota swine industry is for groups of producers to form networks in which they own sow units jointly. The individual producers then purchase early-weaned pigs from the jointly owned sow unit at the cost of production, and finish the pigs independently, perhaps marketing under a marketing contract negotiated as a group. There were ten operations with wean to finish enterprises that were summarized in the 1997 SWFBMA report. Most of these are believed to be getting pigs from networked sow units, although perhaps not all of them did. They averaged a positive net return of $11.32/head or $21.77/hour. There were seven wean to finish enterprises in the 1998 summary. They received an average hog price of $42.28/hundredweight compared to the $34.69 received by the finishers, probably due to a higher level of marketing contract usage. They still lost an average of $-0.31/head or $-0.66/hour, but this was still quite a bit better than the results for the independent finishers.

Poultry Farm Profitability

How have contract livestock and poultry producers fared financially in recent years? Contract poultry production has had a reputation in recent years of being a fairly low-return enterprise. Empirical evidence on the financial performance of farms with broiler contracts is provided in a recent USDA report. Broiler farms with sales of $50,000 are compared with 1) other farms growing just crops and 2) farms with other livestock but not contract broilers. The report is based on 1995 data from the Agricultural Resource Management Study (formerly known as the Farm Costs and Returns Survey (Perry and others 1999). It also discusses the types of contractual arrangements in use. Broiler farms were in fair financial condition in 1995, with net farm income of $15,969. They had less invested in the business than other farms, and worked fewer hours on the farm. The broiler farm net farm income was less than half of the average $38,966 earned by other farms. One question the analysis does not address is whether the broiler farms would have earned more if they had been engaged in some other enterprises, or whether they chose broilers in the first place because their resources were too limited for other enterprises. The broiler farms averaged $392,353 in farm equity compared with $673,155 for other farms.

One interesting fact identified in the study is that, on average, spouses were more heavily involved in decision-making and management, and worked more hours, on broiler farms than on other farms with comparable sales. Three quarters of the broiler producers said that their major occupation was farming. These operators' household income was 78 percent of the average U.S. household's income, largely due to lower off-farm income. There does not seem to be any comparable financial analysis of other commodities' contract production done on a national basis.

Table 30. Financial Performance of Independent Hog Finishing and Contractee Hog Enterprises in MnSCU and SWFBMA Summaries, 1994-98

	1994	1995	1996	1997	1998	Average	Average
	------S. Central and SW MnSCU & SWFBMA ------			--- Statewide MnSCU & SWFBMA ---			
Independent finishers						(1994-98)	(1997-98)
Number of farms	235	168	134	182	163	176	173
Hog price/hundredweight	40.96	43.88	54.81	$ 53.37	$ 38.86	$ 46.38	$ 46.11
Net return/pig produced	(0.33)	10.11	13.13	$ 5.82	$ (14.13)	$ 2.92	$ (4.16)
Hours of labor/head produced	0.44	0.41	0.48	0.48	0.42	0.45	0.45
Net return/hour of labor	(0.75)	24.72	27.41	$ 12.17	$ (33.75)	$ 6.56	$ (10.79)
Contractee hog producers							(1997-98)
Number of farms			(data not	41	51		46
Net return per pig space			available for	$ 4.78	$ 3.75		$4.27
Pigs produced/pig space			1996)	2.64	2.81		2.73
Net return/pig produced				$ 1.81	$ 1.33		$1.57
Hours of labor/pig space				0.51	0.46		0.49
Hours of labor/head produced				0.19	0.17		0.18
Net return/hour of labor				$ 9.35	$ 8.06		$ 8.74

Question E2b. What are the comparative internal economic costs and benefits of various livestock production systems?

Alternative Swine Systems

Basic information about conventional swine production systems, including some information on investment and profitability, is available in (Anonymous fact sheets individually dated). There is a great deal of interest in alternative swine housing and production systems, especially hoop barns, pasture farrowing, and the Swedish deep-bedded system. (Honeyman 1996) lays out the requirements for a sustainable swine production system, with characteristics such as industry structure, barriers to entry, diversity, utilization of manure and dead pigs, and pork quality. He lays out four levels of issues, from the farm, the rural community, the society or consuming public, and the ecosystem or environment. Another overview of alternative swine systems is provided in (Anonymous 99d).

Two sources of descriptive information about the Swedish deep-bedded system are (Honeyman 1995) and (Halverson and others 1997). Neither of these publications includes an economic comparison of the Swedish system versus conventional confinement systems.

Dutch swine researchers have studied different housing systems for pregnant sows at the Rosmalen Research Institute for Pig Husbandry. (Backus 1997) is a summary of several research projects conducted between the late 1980s and 1994. Generally, they found that technical performance of group-housed dry sows was similar to sows housed individually in gestation stalls. They conclude that group housing is economically feasible, but will require more management skill by the farmer compared to individual housing.

Producer-oriented planning information on hoop barns is provided in (Anonymous 1997b). According to their economic analysis, hoop barns as swine housing do not have a great economic advantage or disadvantage compared to conventional confinement buildings. Hoop barns involve a lower initial investment but higher operating costs, and little history exists to show how reliable and durable they will be.

One budget analysis of swine production systems under Minnesota conditions is (Lazarus and others 1991). The purpose of this study was to evaluate the potential economic impacts in representative swine facilities of adopting production systems and equipment which address selected animal welfare concerns. Specific systems studied included:

- conventional, confinement breeding herd housing and finishing
- outdoor farrowing, one litter/year and two litters/year, with confinement finishing
- gestation stalls which allow sows to turn around and move more than conventional stalls
- electronic sow feeders with pen gestation
- straw-bedded, solid-floored sow housing with individual farrowing pens
- sow-pig nursery where weaning is delayed and pigs are moved less frequently
- marketing lighter-weight, intact boars rather than castrating

All of the alternative systems were found to reduce profitability compared to conventional confinement systems to some degree. The electronic sow feeder system and the turnaround

gestation stalls had little impact on profitability, while the outdoor farrowing and straw bedded systems increased costs by about $4-5.00 per hundredweight of pork produced. As in any pro forma budget analysis, the study was based on expert opinion about hypothetical situations, because few or no commercial farms were using these systems at the time, so actual performance may be different from what was projected.

There is considerable interest in the economic viability of alternative swine production systems that require less investment, or offer improved animal welfare or working conditions that are different from those in environmentally controlled confinement buildings. A project currently underway under the University of Minnesota's Minnesota Institute for Sustainable Agriculture is intended to produce case studies and business record analyses of a set of Minnesota swine operations that are using alternative systems such as hoop barn finishing or pasture farrowing. The project goal for 1999 is to identify the farms and help them to standardize their financial records in a form that can be used for comparative analysis, probably using the University of Minnesota's FINPACK farm financial analysis software through the Minnesota State College University's farm business management program. It will probably take three or four years of data to produce an adequate picture of the long run comparative economics of alternative systems, so useable results will probably not be available until early in 2004.

Oltjen and Beckett discussed the valuable role ruminants serve in sustainable agricultural systems. They are useful in converting vast renewable resources from rangeland, pasture, and crop residues or other by-products into food edible for humans. Further, ruminant livestock production is consistent with proper agronomic practices in which forages are grown on 25% of arable land to minimize soil and water erosion. They point out that net returns from of humanly edible energy and protein are dependent on the production system used. Production efficiency has ranged from 96% to 276% on humanly consumable protein for dairy. Beef production efficiency is highly dependent on time spent in the feedlot. Their protein efficiencies range from 28% to 59%, and energy efficiency from 52 to 104%. They indicate the protein from ruminant livestock production is of higher quality with greater biological value.(Oltjen 1996)

Alternative Dairy Systems

Cornell workers reported on the financial performance of 253 specialized dairy farms in New York state in 1997. These farms averaged 190 cows with 20,651 pounds of milk per cow sold. Net farm income averaged $39928 per farm with a rate of return on assets of 3.2%. Differences in profitability ranged from 15% for the top 10% to –241% for the lowest 10%. Farms adopting bovine somatotropin experienced greater increases in production, had larger herds, and were more profitable than herds not using this technology. Farms adopting rotational grazing generally produced less milk per cow than non-grazing farms, but had somewhat lower costs of production and higher profitability. Large freestall farms averaged the highest milk output per cow and per worker, with the lowest cost of production and investment per cow, and the greatest returns to labor and management. Farms milking three times per day produced more milk and were $.09 per cwt less than herds milking twice daily. (Knoblauch 1998)

Penn State workers reported findings on the performance of 53 representative randomly selected dairy farms in 1993. They found moderate intensive grazing achieved a $129 per acre return to operator labor and management compared to $20 and $58 returns for all hay and maize

enterprises, respectively. Debt per cow was substantially higher for farmers increasing rotational grazing intensity. They indicated that pasture acres per cow, high debt to assets, and negative cash flows provided an important motivation to increase grazing intensity. A drawback of intensive grazing was the likelihood of lower milk production than with confinement feeding while the main economic benefit was a reduction of costs associated with forage production.(Hanson 1998)

Minnesota workers compared milk production and profitability for confinement feeding and rotational grazing with Guernsey and Guernsey X Holstein cows grazing perennial rye grass pastures from mid-May to October. Over the two year period confined cows produced 7% more milk with similar fat percent compared to the grazed animals. Body weight change and health were similar for both groups. Net return per cow averaged $64 greater for the rotational grazed group because of lower cost for feeding, facilities, equipment, and labor. They point out that stored feeding is still required from late autumn to early spring in the North USA. (Rust 1995) Minnesota workers surveyed 29 dairy farms using management intensive grazing practices through personal interviews. The respondents cited a change in the use of their time: reduced time doing chores, baling hay, repairing equipment, planting, harvesting, feeding and manure handling, and which allowed more time for duties of managing the pastures and the business. These farms reported reduced input purchases such as feed and fuel. (Loeffler 1996)

Wisconsin workers reported survey results of almost 1200 dairy farms in 1995. About half of the surveyed farms were confinement operations that used no pasture forage. About 35% of the farms rely on some pasture to some degree (non-intensive), and 14% were actively pursuing management intensive rotational grazing of some type for a portion of their forage needs. Of the total farms surveyed, about 8% used pasture as their primary source of total feed during the grazing months. The heaviest concentration of grazers were in three Southwest Wisconsin counties. The authors note the highest adoption rates to be in areas of lower farmland values, but also suggested that social, and institutional factors unrelated to the agronomic and socioeconomic characteristics of the region may have influenced the higher adoption rates. Adopters had smaller herds, less likely to use total mixed rations, rBGH, sell grade A milk, have milking parlors, or use farm business management tools such as DHI records. Grazers spent more total labor hours per cow, had lower farm income, lower capital investments, and higher off farm income. (Jackson-Smith, Douglas Grazing in Dairyland)

Cornell workers attempted to explain why the characteristics of dairy farmers in two different communities with similar resources but quite different in performance may take on certain patterns. This was a study of the human capital component of dairying. Farmers in the two communities were following the same path toward optimization of milk production but receiving very different results. The high production community was more advantageous for formal education, access to markets, and proximity to an urban center. Among the differences found, farmers in the high production community used more techniques associated with good management practices, and they were better educated. (Cruise and Lyson, Cornell). The work is consistent with others that identify the importance of human capital, and management skills in operation of a successful dairy. (Center for Epidemology and Animal Health 1996)

USDA-APHIS conducted an extensive national dairy survey covering the major milk producing regions which was intended to monitor dairy health and management practices. The results

covered herds larger than 30 cows, and reveal management characteristics by herd size and region. There were several areas of management where differences related to herd size were small such as the quality of milk produced and mastitis management control practices implemented (Center for Epidemology and Animal Health 1996). There are major differences in the way manure was handled, stored, and applied to the land. Gutter cleaner use declined and flush systems with recycled water increased in larger herds. More than 90 percent of the herds over 200 cows used some type of liquid manure storage; primarily either a lagoon or a slurry system. Lagoons were more popular in the western states because of greater evaporation from more arid conditions. Most of the smaller herds handled manure as a solid and were more likely to spread manure daily during winter months. The practice of incorporating the manure into the soil within twenty-four hours after land application to minimize odor and nitrogen loss increased as herd sizes increased.

Herd Size and Production Costs

The summary of all herds by profit level suggests large herds produce milk at a lower cost and have a higher return than small herds. (Jackson 1999) The 1996 Minnesota Farm Business Management records were summarized by high and low profit groups within 6 herd size classes to gain more insight. The results suggests production cost per 100 pounds of milk to be similar for the high profit farms within all size categories except the very smallest herd size group. The Margin of difference between the low and high profit herd within the size groups diminished as herd sizes increased. The cost structure appears to change with different size herds. However, some caution should be used in this conclusion because of the smaller number of herds in the largest group and a relatively higher portion that were in a typically more costly herd expansion period. This summary shows wide differences in the cost and returns in all the size classes from herds less than 30 cows to those over 200 cows. The summaries are based on costs and returns per cwt. of milk (Figures 1 through 6) and Figure 7 represents total returns from the dairy herd.

Figure 1. Milk Production Per Cow By Profit Levels Within Herd Size Classes

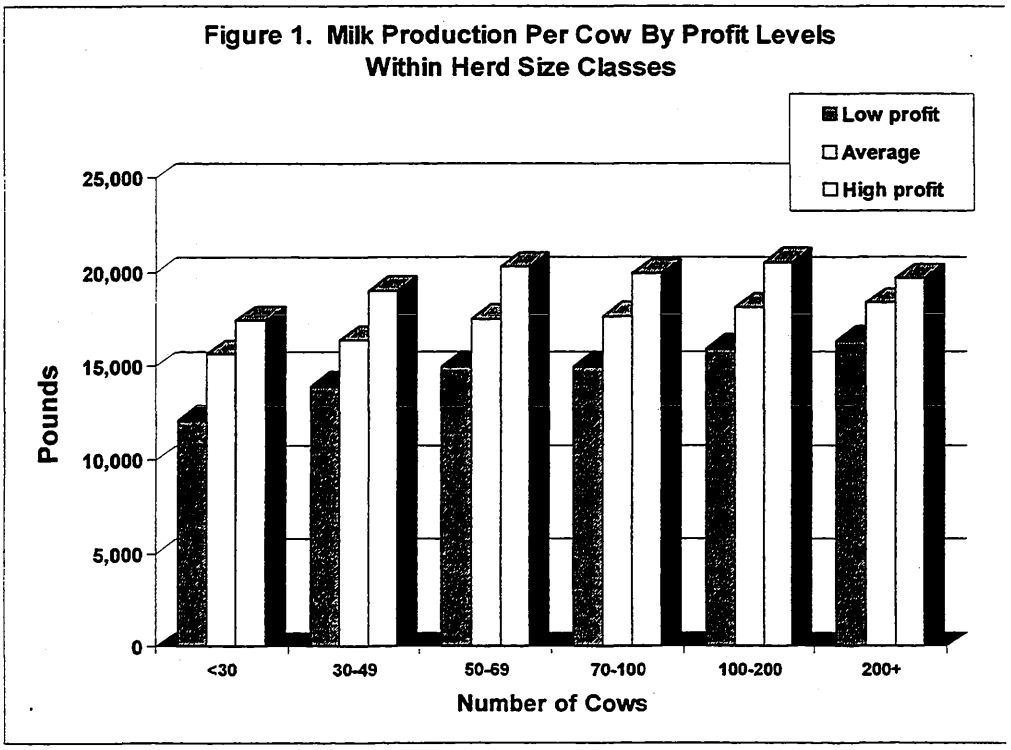


Figure 2. Gross Income Per Cwt By Profit Levels Within Herd Size Classes

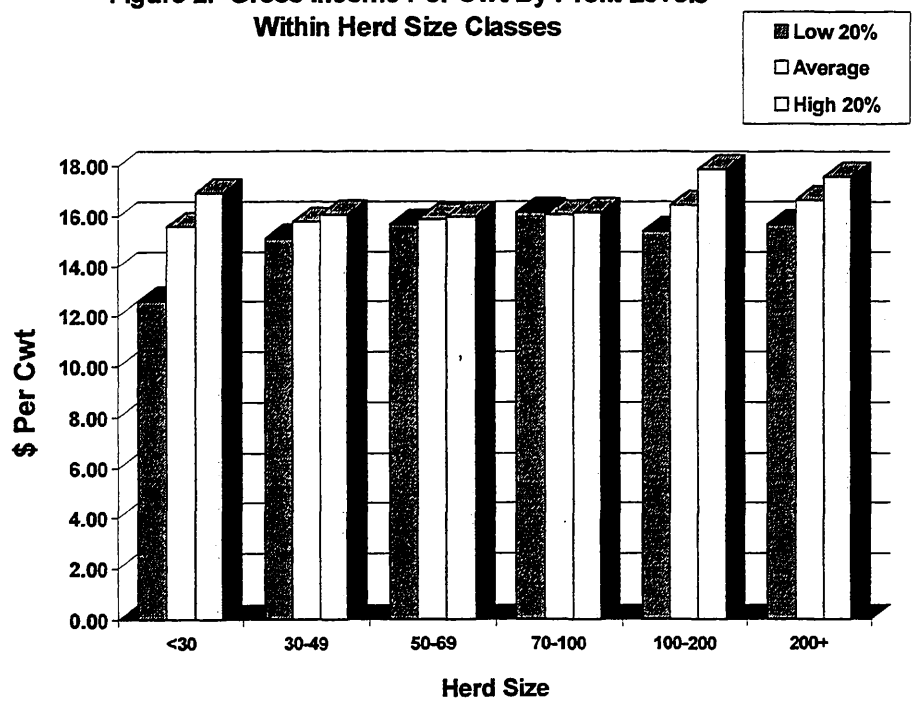


Figure 3. Total Cost Per Cwt By Profit Levels Within Herd Size Classes

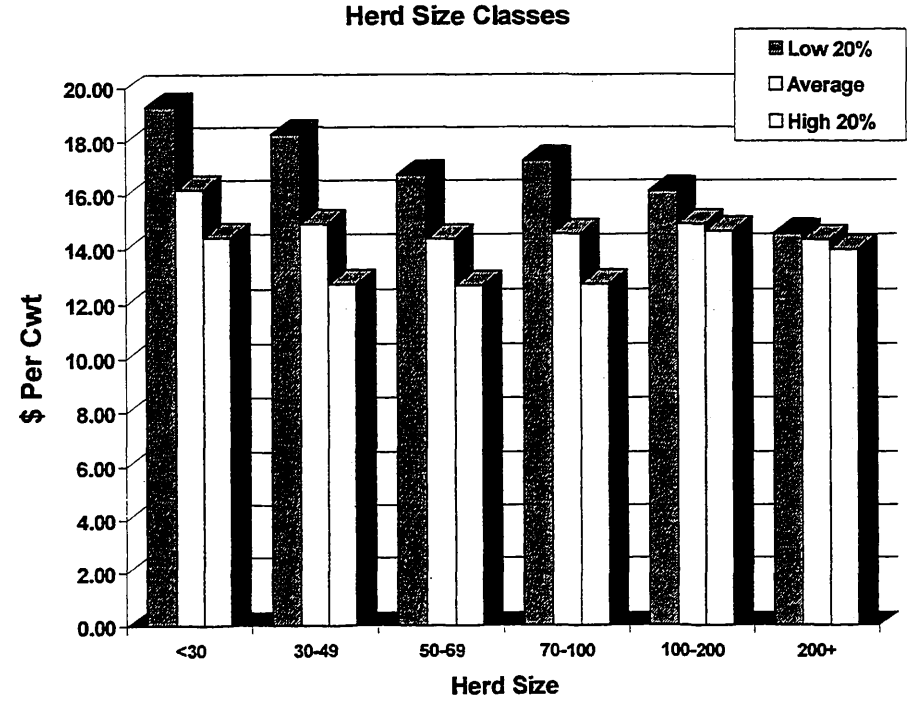


Figure 4. Feed Cost Per Cwt By Profit Levels Within Herd Size Classes

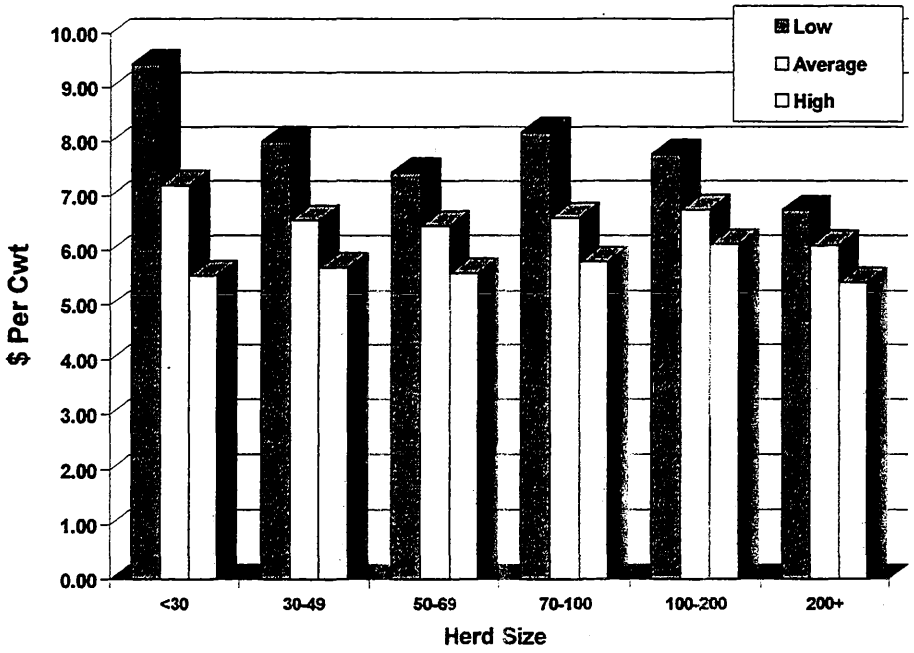


Figure 5. Herd Replacement Cost Per Cwt By Profit Levels Within Herd Size Classes

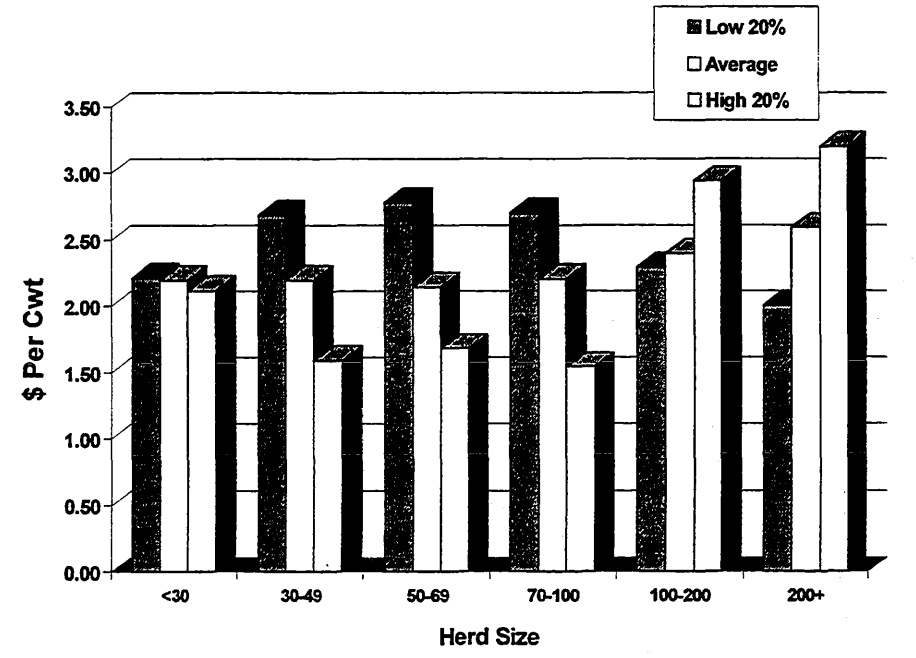


Figure 6. Net Return Per Cwt By Profit Levels Within Herd Size Classes

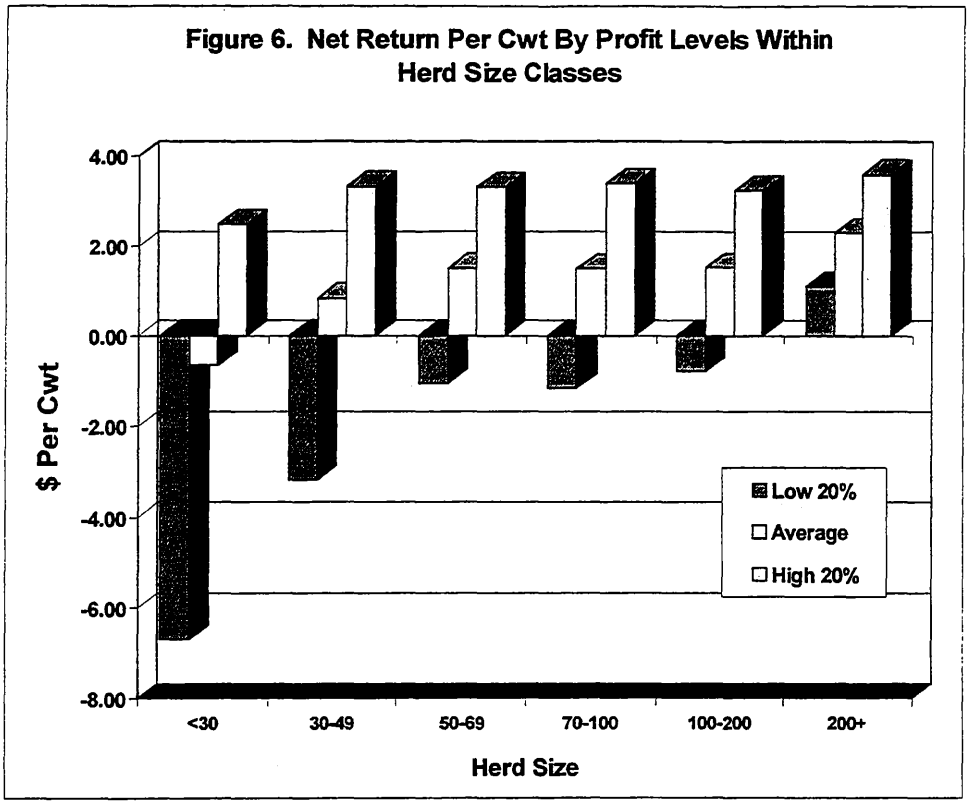
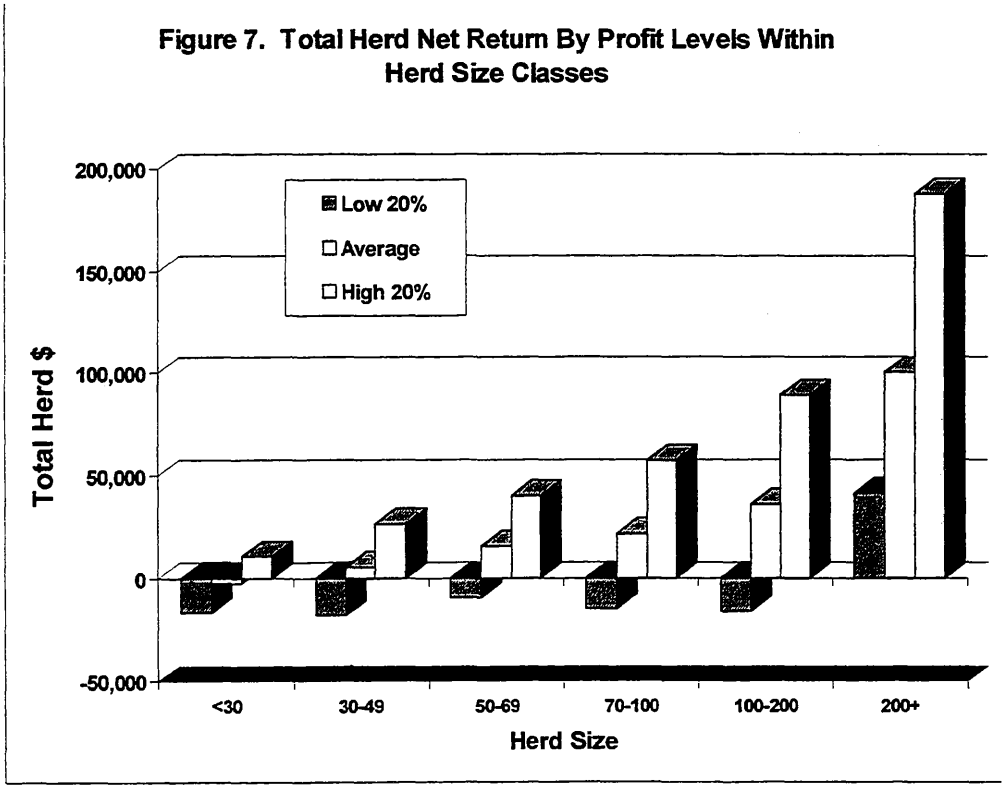


Figure 7. Total Herd Net Return By Profit Levels Within Herd Size Classes



The highest average cost was for herds less than 30 cows ($19.30 per cwt) by a big margin and lowest for the largest herd group ($14.32) by a small margin compared to the other size groups above 30 cows. The spread between the low and high profit groups was greatest in the herds less than 30 cows ($14.92 vs. $19.30 per cwt) and this spread between profit groups tended to be smaller among the larger herds. Feed cost per cwt of milk ranged from $5.41 for the most profitable herds with over 200 cows to $9.42 for the low profit herds with less than 30 cows.

There was also much variability in the gross income per cwt, ranging from $12.61 per cwt for the least profitable herds with less than 30 cows to more than $17.50 for the most profitable larger herds. Milk price was only a part of this variability; just as important were the sale of culls and other animals, and changes in animal inventory from one year to the next.

The difference in returns per cwt between high profit large and small farms were relatively small compared to the larger differences between high and low profit farms within the size classes. Returns per cwt were negative for the low profit herds in all size classes except the largest. Low productivity, feed costs and change in animal inventory are major contributing factors to lower returns in all size classes. The profitability margins per cwt were similar for the high profit groups for all size classes but the smallest herds. (Conlin 1998) These Minnesota results are consistent with those of Ford et al.

Interpretations of farm level data can provide valuable insights but conclusions are limited by the by the data sample, and wide variability among farms and years. For example the number of herds in the largest group in the above data was relatively small, 11 herds. Availability of financial performance of larger Midwest dairies is very limited. There are other data sets that have been collected within the private sector that are not available in that they are proprietary. More intense statistical analysis on issues of size and scale efficiencies, alternative dairy farming systems and strategies to optimize use of resources is needed to provide more conclusive evidence. Development of an ongoing program to monitor and provide performance benchmarks for comparisons by producers would provide a valuable management tool.

The most significant issue is to market enough milk to generate the desired level of family income. Unprofitable farms have significant opportunity to enhance their profit level through improved management control and increasing productivity. Adding cows to an unprofitable dairy is seldom an effective strategy. The more profitable dairies are the best candidates for increasing family living through increases in cow numbers.

It is useful to compare the discussion in the previous few paragraphs to the discussion of the "L"-shaped cost curve under question E1. Note that the last paragraph focused on income for family living, not efficiency or per unit cost.

> "This is an important point for two reasons. First, many people assume that the larger units are needed for efficiency and that to keep the costs of food low farms have to be big. Second, the current production techniques we employ narrow the profit margin for the farm. They are getting bigger for the income not to lower costs of production. Realizing this opens more options for the farmer and society to pursue if the increase in size is for income not efficiency." (see reviewer comments)

Many of the already profitable dairies will need to increase herd size to maintain a competitive and viable dairy farm business. Increasing cow numbers in an unprofitable or marginally profitable dairy business has a poor chance for success. The profitability problems should be solved first. The above discussion based on review of literature and farm financial records.

Many upper Midwest dairy farms are at a crossroads in trying to find better ways to reach their goals. Profitability and family lifestyles are two primary driving forces. The typical upper Midwest dairy farm is highly diversified in demands for capital, labor and management know-how. All of these resources are stretched so thinly that it is often difficult to compete. Farm families are looking for ways to work smarter, not harder and longer.

Options under consideration include: grazing, expansion, use of consultants, networking with other farmers, specialization, contracting, exiting the dairy business, surviving to retirement, etc. In 1994, a University of Minnesota study explored three alternative dairy production systems:

1. Purchasing all feed on minimum land base.
2. Raising forages and purchasing grains and concentrates.
3. Raising forages and grains to feed the herd.

The analysis was based on a new start-up dairy with the land and field machinery investment determined by the cropping plan. The systems were analyzed over a range of herd sizes from 138 to 828 cows. The dairy facilities, parlor, manure system, feed storage and housing were designed to meet herd sizes. Summary results are shown in Table 31.

Table 31. Economic performance comparison of three dairy farming systems.

	Herd size (stalls/cows)					
	100/138	200/276	300/414	400/552	500/690	600/828
Total assets, $/cow						
Purchase all	3,361	3,152	2,997	2,883	2,845	2,859
Raise forages only	5,393	4,831	4,590	4,447	4,402	4,410
Raise forages & grains	6,594	5,863	5,603	5,391	5,334	5,300
Return on assets, %						
Purchase all	2.5	9.9	12.8	15.6	16.8	17.5
Raise forages only	5.8	11.5	14.2	16.1	16.8	17.2
Raise forages & grains	4.7	10.0	12.4	14.3	15.2	15.5

University of Minnesota, 1994.

These estimates would be most representative of a new start-up dairy and may not be applicable to an individual farm or an existing dairy operation that is planning to expand. The results suggest some key points:

1. Dairying is capital intensive and there are substantial capital efficiencies gained up to 300 to 400 cows for all three systems. Gains are still realized beyond 400 cows but at a

slower pace. These capital efficiencies are largely due to dilution of two large fixed cost items: the milking center and waste management systems. These costs are not increased greatly by increasing cow numbers.

2. Cropping machinery and the land base required to produce the herd feed supply add greatly to the capital requirements. Capital investment requirements are reduced by 15 to 20% for the option of raising forages and buying grains compared to raising all the forages and grains. The capital investment was further reduced by 40 to 45% for purchasing all feed.
3. Increasing returns on assets (profitability) demonstrates substantial scale efficiency. Returns on assets increased most up to 300 to 400 cows, then more slowly up to 800 cows. This was true for all three systems.
4. Profitability levels (return on assets) favored the two more highly specialized systems: purchasing all feed, and raising forages only. The more diversified system of raising all feeds was the least favorable relative to returns on assets, but still acceptable at larger herd sizes.

Making the leap to a full-fledged modern system is not feasible for many of our current dairy farm businesses. The availability of the investment capital needed to move out of the stall barn to a modern freestall system with pit parlor milking in one step requires a major investment of new capital and additional management competencies. These units have to be large enough to dilute a large capital cost with enough cows to be profitable. Milking centers with pit parlors and manure systems are typically the largest fixed cost items in these new systems. A 1994 Minnesota study showed 400 to 500 cows were needed to achieve an acceptable level of return on assets of at least 12%. Typically, the capital requirements for developing complete new units from the ground up are $1.5 to $2.0 million or $3,000 to near $4,000 per cow. This level of investment may be beyond the available loan capital and/or the tolerance for financial risk for many dairy farm families. The Minnesota study illustrates the impact on the investment per cow if all crops and only forage crops are raised compared to purchasing all the feed. (Conlin 1998b)

Discussion of the Dilemma of Growing Cow Numbers

Most upper Midwest dairies are relatively small herds in stall barns that have reached obsolescence. Modern freestall barns coupled with milking centers are more labor efficient, kinder and gentler on the backs and knees of millers, are well ventilated, provide a healthier and more comfortable animal environment, are easier to adopt new technologies, have major scale efficiencies in investment per cow, and are more flexible for growth options in the future. Finding a way to move out of the stall barn is a challenge for many wanting a long term, healthy and profitable future in dairying that will enable a quality life style.

The dilemma many face is the lack of adequate capital to quickly modernize to freestalls and pit parlors to support a profitable size at tolerable levels of risk. Few have had experience or training in the skills required to manage these modern dairy systems. Moving out of the stall barn changes the way cows are housed, fed and milked. The move also affects routine work, purchasing feed, handling manure, using consultants, managing people, establishing control

systems, and budgeting and forward planning. The skills of managing finances, production and people can be learned with commitment, study, experience and training.

Typical Midwest dairy farms are highly diversified, raising forage and grain crops for feed for the dairy. Dairy income is the primary income source while the invested capital, labor and management talents are diluted over several enterprises. Many farms can benefit from evaluating which enterprises are contributing most to their profitability and then reallocating their resources to those that contribute most. (Conlin 1998b)

List of Major Relevant Ongoing Work

NE-165 Regional Research Project, "Private Strategies, Public Policies, and Food System Performance," which includes researchers from 24 U.S. land grant universities and several government agencies, was mentioned earlier as a source of general information on structural change in agriculture. Its objectives are to: 1) To analyze the impacts of changes in strategies, technologies, consumer behavior, and policies on the economic performance of the food system, and 2) To provide economic analysis of private and public strategies in order to assess their impact on improvement in food safety and other quality attributes. The administrative advisor is Dan Rossi at Rutgers University, Cook Office Building, 55 Dudley Road, New Brunswick, NJ 08901, Phone: (732) 932-9155. Termination date is 9/30/2001.

Northeast Regional Research Project NE-177, "Impacts of Structural Change in the Dairy Industry," has two objectives, 1) Determine the interrelationships among and relative importance of social, economic, technological and political environments, regional conditions, and entrepreneurial strategies affecting restructuring of the dairy industry in different dairy localities, and 2) Identify, examine, and assess the effects of structural change in the dairy sector on local communities and related enterprises. The chair is Douglas Jackson-Smith, University of Wisconsin-Madison, Program on Agricultural Technology Studies, 1450 Linden Drive, Rm. 146, Madison, WI 53706-1562, 608-265-2908. Termination date is 9/30/2001. Three states (WI, MI, and NY) have done one or two years of survey work in a dairy-dependent community in the state. Several other states, including Minnesota, have only participated in a limited way due to lack of operating funds and faculty time.

The Alternative Swine Production Systems project is a project funded by the Minnesota Legislature and organized by the Minnesota Institute for Sustainable Agriculture, a partnership between the University of Minnesota and the community as represented by the Sustainers' Coalition. Its major objectives are to 1) research and develop low-emission and low-energy alternative pork production systems, 2) promote alternative pork production systems, including hoop houses, the Swedish model for farrowing and feeder pig production, and pasture farrowing, and 3) disseminate information on new low-emission and low-energy alternative pork production systems to farmers and agricultural service providers including lenders, educators, and vendors. One component of the project is to conduct case studies and summarize production and financial performance data for farms using alternative swine production systems. Farms are currently being identified for the study, and the expectation is to assist the farms to implement a standardized financial analysis system for the year 2000 calendar year. Given the year-to-year variability usually experienced in financial performance of individual farms, several years of data will be needed to make credible comparisons between alternative and conventional swine

production systems. The project coordinator is Mr. Wayne Martin, Associate Program Director, Alternative Swine Production Systems, University of Minnesota, (612) 625-6224, 385E Animal Science Building, 1988 Fitch Ave., St. Paul, MN 55108.

A comparable project on financial performance of alternative swine systems is also underway at Iowa State University. The contact person is Professor Jim Kliebenstein, Department of Economics, Iowa State University, (515)294-7111, Ames, Iowa (Kliebenstein).

There are a large number of individual agricultural experiment station research projects at north central U.S. land grant universities that relate in a very general way to the GEIS study questions, but nothing seems focused very specifically on any particular questions. Topics include revitalizing or improving the profitability of particular livestock enterprises or production systems; improving marketing practices; assessing the economic potential of particular livestock industries in a locale; assessing linkages between economic, environmental, and quality of life indicators; and assessing public policy. Project descriptions are available on the USDA National Agricultural Library's Current Research Information System web site http://cristel.nal.usda.gov:8080/.

A north central regional extension task force is continuing to develop materials related to alternative swine production systems such as (Anonymous 1997b). The administrative advisor for the task force is Elbert Dickey, Associate Dean, Cooperative Extension Service, University of Nebraska - Lincoln (Brumm).

Recommendations for Additional Future Research

Question D2. With respect to the following factors, what is the current situation in the Minnesota livestock industry, what are the changes taking place, why are the changes occurring, and what are their implications:

a. geographic distribution and

d. competitiveness in national and international markets

At the county level, if there was a single aggregate indicator of the restrictiveness of county feedlot ordinances or local opinion (and to our knowledge there is no such indicator at this time), it might be interesting to examine the correlation and causal relationships between market share and that indicator.

One question that was raised in the GEIS discussions is whether there are other states or regions where a type of livestock production was declining and then rebounded, and what had been done to bring about the turnaround. The Missouri swine industry is the main example that has been identified, but we have so far been unable to find a concise summary of the history which documents the timelines, what was done, what proved effective, and the economic, social, and environmental impacts of the turnaround. This could be a subject for future economic and sociological research.

type of business organization and degree of vertical integration or coordination

If more information was desired on this topic, the type of information presented in the 1993 Packers and Stockyards study could be updated with an emphasis on Minnesota. This might involve interviews of such industry leaders as Hormel, Swift, IBP, Cargill, LOL, Hubbard, Harvest States, and large Minnesota pork and dairy producers, for an MS or Ph.D. thesis.

Question D1b. To what degree are livestock producers allowed to operate agricultural systems interdependently as opposed to independently in Minnesota and in other states and what is the significance?

A more in-depth research approach than that used by Mo and Abdalla might be to describe the ownership and control structure of interdependently-operated agricultural systems which are operating in at least one state, and then to compare their structure with the restrictions in other states of interest. If the restrictions would prevent their operation "as is", a further step would be to determine what adjustments in the ownership and control structure would be required to comply with the other states' rules, and to use some sort of economic simulation model to estimate the impacts on profitability. Figuring out what adjustments would be most realistic and the cost of each would be difficult. If the economics favor an interdependent structure, then entrepreneurial farm operators tend to exercise considerable ingenuity in coming up with new business arrangements to take advantage of the opportunities within the legal restrictions they face. It may be difficult for a researcher to anticipate the array of adjustments that entrepreneurs may come up with. For example, it has been suggested (but not proved!) that the present use of production and marketing contracts in swine production is a result of corporate farm laws which prevent coordination of production through direct ownership. Perhaps another example might be use of limited liability partnerships for Minnesota dairy farms as a way of involving more than the five unrelated owners allowed for an authorized farm corporation.

The business organization form known as a Limited Liability Company or LLC, which is not allowed for agriculture in Minnesota, is another alternative to an authorized farm corporation as a way for farmers to operate interdependently. The administrative costs of setting up and operating an LLC are said to be less than for a corporation, so documenting those differences could be one aspect of this research.

Another research topic that was suggested in the GEIS discussions would be to quantify the extent to which farm operations are utilizing multiple forms of legal organization, business arrangements, and capital sources as described in Boehlje and Lins.

Question E2a. How is the profitability and economic viability of farms and firms affected by different production and marketing arrangements?

Perhaps more work could be done on different production and marketing arrangements affect costs at different stages of the supply chain, and which players in the supply chain would benefit from the improvements in the short run and in the long run, along the lines of the publications by Martinez and others that were cited.

Much of the debate about the fairness of long-term hog marketing contracts revolves around whether quantity premiums paid to producers under long-term marketing contracts or for larger

spot market lot sizes are unreasonable compared to what is paid for smaller spot sales (see, for example section V of Land Stewardship Project). "Reasonableness" relates to how such premiums compare to differences in packers' procurement and operating costs. Specific research needs include: 1) how packers' hog procurement costs vary with lot size (number of animals involved in the individual transaction), and 2) how much slaughter plant per unit operating cost increases when the plant is operated below or above optimum rates on any given day. These cost differences are difficult for university researchers to study, due to lack of access to individual transaction and contract data. This may be an area that can only be effectively researched using data obtained under the auspices of the USDA Packers and Stockyards Administration's or other government agency's subpoena power.

Question E2b. What are the comparative internal economic costs and benefits of various livestock production systems?

As was mentioned in the critique of the study questions, one issue that is not specifically is the impact of possible higher future energy prices on the ways livestock is produced and marketed. This is a question that often comes up in discussions about the future of agriculture. This is a possible topic for future research.

More research is needed to better understand and the factors driving profitability, and development of models to help farm operators to strategically optimize the use of farm resources in the context of limited assets in order to achieve environmental and farm family life quality goals. These studies would include assessments of the cost and returns of environmental stewardship practices, adoption of technologies, management protocols, alternative business structures and networking with others, transition strategies, to the development of benchmarking and monitoring systems for better control of management processes.

Question D4. What is the current market situation, how is the market changing and what are the implications for livestock producers with respect to the following factors (concentration of buyers, contractual buying and selling arrangements, and price discovery and market fairness):

The studies cited by Azzam and others on policy response to meatpacking industry concentration were done before the disastrous downturn in the hog market in late 1998 and early 1999. Retail pork prices have apparently not fallen as much as many pork producers think they should have in light of how little producers have been receiving. A specific question which this report does not address in detail is, "What is the farm-retail margin for pork and other livestock products, why have retail prices not fallen further, and who has been benefiting from recent increases in the margin?"

The main source of information on farm-wholesale and wholesale-retail margins is the USDA Economic Research Service. The estimation of margins is becoming more complicated as product mixes change and the production, processing, and distribution stages become more integrated, as has been noted by some of the authors cited in the report. For example, more and more meat reaches consumers in further processed products such as pizza which include dairy products and other components. Putting a retail value on the meat portion of such products can

be a challenge. The USDA margin figures are probably the most accurate available, but their exact magnitude needs to be viewed cautiously.

One reason economists feel that retail prices did not fall further was that limited slaughtering capacity would have made it difficult to move more meat through to consumers even if price reductions had stimulated demand. Normal price lag times and the cost of processing/distribution labor, packaging, shipping, etc. may have been other factors limiting retail price discounts, but few specifics are available at this point. This is a matter of considerable debate at the present time, and is an important topic. The time constraints under which we were operating did not allow us to address it.

APPENDIX : RESPONSE TO REVIEWERS

Literature Review

Industry Structure Topic: ***Summary of Comments on the DRAFT Report***
June 15, 1999

1. Some more explanation (if possible) on market share changes
   - Any information on decline/rebounding" areas?
   - Wisconsin differences?
   - Oklahoma differences?
   - California differences?
   - Brazil, Canada, European differences?

Response: Added a table with market share data for other species like the existing dairy table. Expanded discussion of Hayenda et al.'s paper on international competitiveness of pork. Missouri is the main example of decline then rebound. So far, we have not found a concise summary of their public sector activities related to the rebound – topic for possible future research.

2. Impacts on Industry Structure

   - Impact of environmental regulations on livestock industry – only Pennsylvania State study? Effects on cost of new construction?
   - Any research on antitrust intervention?

Any research on impacts on different production system.

--and--

3. Processing
   - Clarify Azzam's definition of "innovation".
   - Any research on alternatives farmers have to large processors? (Direct marketing one example).

Response: Still haven't found anything beyond the Penn State study on impact of environmental regulations. We have expanded the discussion of buyer concentration, contracts, and antitrust issues. Added discussion of 400-page Purdue study of the food system, which has quite a bit on the processor situation. Will add a discussion of value-added enterprises.

4. Specialization vs. diversification
   - Explain dynamics.

Response: Some of this is described under topic E on profitability. There is also quite a bit in the Purdue study mentioned above.

5. Concentration
   - Rationale for meat packing concentration .
   - Do producers lose market access as a result – why? Why not?
   - What about other reasons for concentration that might not be in economic trend information (ex: business school recommendations?).

Response: We have added several references to Dept. of Justice and Packers and Stockyards Administration websites with general information about their responsibilities. We have added several

additional listings of previous literature reviews on concentration such as Strange and Higby, Land Stewardship Project, and Kinsey. "Rationale" may get beyond what can be documented, into interpretations and value judgments about fairness that we may not be able to describe in ways that everyone will agree on.

6. Consumer Behavior
   - Consumer preferences for food quality/impact on product.
   - Consumer right to know.
   - Cross reference: Social and role of government.

Response: Added some discussion of Connor et al. chapters from Purdue study. "Consumer right to know" doesn't seem to fall under our topic – maybe should be under the "Human health" topic?

7. Ownership
   - Disclose ownership (cross reference role of government).
   - Who owns the animals? What is known about trends?

Response: Could not find much that seemed relevant.

8. Competitiveness
   - Federal price reporting (role of government).
   - Trend toward less access to information – privatization.
   - Research on ability to sell a product.

Response: The new Land Stewardship reference provides details on federal government legal authority to require price reporting.

9. Corporate Farm Law
   - Impact?
   - Evaluation of corporate farm law.
   - Other state corporate farm law – update or delete map?
   - Cross reference role of government.
   - Poultry and dairy exemptions.
   - Combining legal entities?

Response: We have refined the discussion of state laws. We haven't found any other studies of their impacts. We have added a note about possible future research on use of multiple legal entities and business arrangements.

10. Clarification
    - "Cattle"/"cattle on feed" agricultural statistics?
    - SWFBA Explain on page 47?
    - Dairy/swine data. Explain limitations of data.
    - Page 53 "stay in" price.

Response: Added text on each of these items.

11. Report Format
    - Summary bullets.
    - State upfront when there is a dearth of research.
    - Cross referencing to other topics.
    - Executive Summary.

Response: We have tried to clarify the text in the executive summary and elsewhere to make it easier for readers to focus on important implications for Minnesota. On the second point, the issue isn't so much that there is a dearth of research but rather deciding what the real question of interest is and how far afield to go in citing research that is available. Almost the entire body of agricultural economic research could be construed to relate in one way or other to the study questions as they are listed. It is a tremendous challenge deciding where to set the boundaries for which literature to consider "related."

Literature Review
Profitability & Economic Viability Topic: Summary of Comments on the DRAFT Report
June 29, 1999

Clarifications

- What is the definition used for "contractee"?

Response: Self-described but generally does not own the animals - added note in text.

- To what extent does or can the report examine what the situation is in European nations?

Response: Added a section on this. It does not do justice to the issue, but is the best we could do in the time available.

Financial data questions

- Does the data cited about production systems include "modern" systems?

Response: It is pretty clear that the swine farm business summary data included does not include the "mega" operations selling 500,000+ animals per year, and probably few if any operations in the 50,000-500,000 size range although there may be some individual operations represented that are members of networks in that size range. Most are smaller, although some probably utilize much of what is considered "modern" technology today. Expanded the discussion on industrialization in the swine industry, including the role of technology.

- Time and size in data

Response: I believe this comment related mainly to the table comparing contract vs. independent hog finishing, and the desirability of making this comparison over a longer time period as well as the size issue addressed in the previous response. The years we included are, unfortunately, the only ones available.

- Can comparisons similar to the ones given for hogs be repeated for other livestock types as well?

Response: This related to the contract vs. independent hog finishing comparison as well. There is a discussion of a USDA report on financial performance of contract broiler operations elsewhere in the report, although they did not compare against independent broiler production because little exists. The farm business summaries do not include contract enterprises for livestock types other than hog finishing because there are few if any member farms who have such enterprises.

- Explain the reasons behind the hog production price differences between systems in more detail

Response: This refers to the table comparing hog farms in the farm business summaries. The summaries, unfortunately, do not provide any explanation for such differences. We have included a few sentences with our speculation as to the reasons, but we don't know how important the listed possible reasons really are.

- Discuss the representativeness of the data sets in more detail

Response: Added a table and some text on this.

Context questions

- Provide broader discussion of the "L-shaped" curve and its limitations--does it oversimplify matters?

Response: This is pretty well covered in the text that has been added since the draft which the committee reviewed. Our view is that it does not oversimplify, but it does refer only to aggregate comparisons across large groups of farm, and there is always going to be variation present in individual farm data.

- Explain the relationship/differences between economies of size, profits and income as it relates to farm planning

Response: This is also pretty well covered in the text that has been added since the draft which the committee reviewed.

- Provide more of a context for the numbers cited--how do they relate to our "bigger questions" about animal agriculture

Response: It is not clear exactly what they mean by the "bigger questions," and there are 31 tables of numbers which address a wide range of study questions. So, there doesn't seem to be a simple response to this question. This will have to wait until the committee reviews the final report and formulates more specific questions.

- What is the relationship between being a "low-cost producer" and long-term economic survival?

Response: This is also pretty well covered in the text that has been added since the draft which the committee reviewed. Obviously, the closer a given producer is to being the lowest-cost producer in the industry (and ignoring output price differences among producers), the better that producer's chances of long-term survival. However, in the text we explain that producers with costs that are higher than the minimum may also survive especially during favorable economic times but may be more likely to exit during downturns.

Miscellaneous questions

- Is there data available about the impacts of regulatory compliance?

Response: One study has been added on this. We couldn't find very much on this, which we attribute at least in part to the fact the regulations are changing so fast that by the time any study is completed, there is a high likelihood that the particular set of regulations it analyzed may have been changed thus invalidating the results.

- Is there data available about the impacts of the availability or loss of infrastructure? Are costs of locational differences factored into the numbers--such as transportation costs to processors?

Response: These two questions may have related mainly to the farm business summary data. That data does not contain enough detail to answer the second question. The first is an important question that lots of people have been concerned about for many years. We are not aware of any empirical studies that address this, although infrastructure was not specifically listed in any of the study questions and we have not searched specifically on infrastructure. The agricultural business retention and enhancement projects that have been conducted on the swine, dairy and sheep industries included questions on producers' views as to the adequacy of various kinds of input suppliers they used. They did not address the impacts of loss of those suppliers. This issue seems to be something that needs to be addressed together with the larger issue of the viability of rural communities and the agricultural sector in the state, and policy responses to improve that viability.

- Can the differences in production costs by farm size be further explained?

Response: The summaries, unfortunately, do not provide any explanation for such differences.

- Can the generally good profits of 1995 and 1996 be explained?

Response: For swine, this was due mainly to cyclical price highs, which received some degree of boost due to disease problems in Taiwan and Europe which raised hopes of improvement in export markets. All livestock species experience some degree of cyclical fluctuation in production and prices. Swine, in particular, has seen greater price swings in response to a given change in supply in recent years compared to earlier. The reasons are unclear and subject to debate.

- Elaborate on the relationship of off-farm income to total family income--is it generally associated with higher or lower total incomes?

Response: This related to the Peterson regression analysis, but that study did not really address this question. Rather, it found that days of off-farm work helped to explain differences in the ratio of (out-of-pocket farm expenses to farm sales) in 1987 state-level census of agriculture data. He did not have information on either off-farm income or total family income.

Comments of External Reviewers

The authors wish to thank six anonymous reviewers for their comments on earlier drafts of this report. The conclusions of the report, and any remaining errors or omissions, are the sole responsibility of the authors.

Reviewer #1

EXTERNAL REVIEWER FORM

State of Minnesota Animal Agriculture Generic Environmental Impact Assessment (GEIS) Literature Review

Topic: IID. Industry Structure and Competitiveness

1) General Comments on the Report (i.e., is the information and data in the data complete, accurate, and understandable?)

I read through the whole report and found it to be written at a level that would be quite understandable to lay audiences. As for completeness, any report is as complete as available data allow. Certain sections, however, like D4 could benefit from some table showing national trends (see below). I did not check for accuracy against existing sources, but I trust that the writer(s) have done their homework in ensuring the data is accurate.

Response: We added some quite a bit of additional data in D4, and added his table in D3c.

I noticed that some sections under questions D2 and D5 are not discussed at all.

Response: We're not sure what he was referring to here. We think we have everything covered at this point, at least to the degree possible.

The report could benefit from having a separate section on implications for Minnesota at the end of each question. The author mentions implications, but they are scattered through the text making it difficult for the reader to distill just what the data all means to Minnesota.

Response: We'll do this to the extent that time allows.

On page 33, second line from bottom, the word "not" should be inserted before the word "concentrated

Response: Fixed.

On page 41, it is indicated that one way in which Minnesota apparently would be able to exercise influence over the meatpacking industry would be to require mandatory price reporting. I would like to suggest a couple words of caution. Mandatory price reporting in a concentrated market could enhance collusion by giving more information to individual packers about the pricing behavior of their rivals. Second, if State regulations increase packer cost, packers, being multiplant firms, could always move business elsewhere and/or bid less for cattle in States that impose regulation.

Response: We added this comment in the text. Of course, this is the sort of prediction that can't really be proven one way or the other, as discussed in the introduction.

2) Did the Document adequately address the original questions as presented in the GEIS Scoping document?

Yes.

3) Is there additional information that should be gathered or additional questions that should be posed and answered to address this topic issue for the animal agriculture (GEIS)?

Under question D4 , it would be useful to add a section on concentration in food retailing. Often, one thinks pricing problems emanate from processing, when, in fact, retailers are just as powerful in setting prices, especially for perishable products. The working paper from the Retail Food Industry Center by Dr. Jean D. Kinsey (Working paper #98-04) has a good review of the literature. ***[Two sentences deleted to protect anonymity of reviewer.]***

Response: Added discussion of Kinsey as well as Strange-Higby on producer impacts.

3) Additional comments:

None

Reviewer #2

EXTERNAL REVIEWER FORM

State of Minnesota Animal Agriculture Generic Environmental Impact Assessment (GEIS) Literature Review

Question 1

1. For lay audiences, I think it would be useful to have more structure to the discussion.

Response: We have tried to integrate the discussion to a greater degree, although the wide range of questions and the instructions to address each specific question, along with our goal of confining our comments to factual ones which the public can agree upon, took precedence and may have detracted from cohesiveness of the presentation.

2. The coverage appears to be uneven -- in some cases there is discussion of both pork and dairy species, whereas in other cases the discussion is exclusively focused on either dairy or pork. It is not clear in many cases whether this is by design or whether there are some pieces missing.

Response: We focused on dairy, pork, or both to the extent that material was available that seemed to be most directly related to the questions.

3. Beef and poultry are not included at all in the discussion. Maybe this is by design since the issues identified by the GEIS protocol only relate to pork and dairy. However, this should at least be acknowledged, particularly since poultry is considered to be one of the most complete examples of a restructured industry where we might be able to learn about the issues/questions being raised concerning the pork and dairy industries. I think a review of the literature concerning the poultry industry is critical because it is often identified as a model or example of what might happen to pork and possibly dairy.

Response: Added a brief discussion of Reimund et al. under D2. There is probably much more that could be done along the lines of comparing the present situation to poultry and other earlier restructuring, if time permitted.

4. Concepts of supply chains, value chains, and tighter linkages with consumers increasing their demand on producers to be qualified suppliers and input supply/biotechnology/genetic/nutritional companies providing the technology to implement biological manufacturing are not covered in the literature review. I think this is a major issue in the restructuring of agriculture and is a critical missing piece of the discussion.

Response:

5. In essence, my concern is that there does not appear to be a story line which is relatively easy to follow through this 50 page document. The literature review appears to be very comprehensive in some areas, relatively incomplete in other areas, but most importantly,

it does not flow as effectively as it might from paragraph to paragraph within each section.

Response: We agree that the discussion may not flow as smoothly as desired. The main reasons are the time constraints we have been operating under, the broad, disconnected nature of the questions, and the fact that there have been two different authors with somewhat different writing styles.

6. Specific comments have been made at various points in the manuscript, but will not be repeated here.

Question 2

1. The questions are so broad and all encompassing that it would in my judgment be difficult to do this literature review. As noted earlier there are some areas/topics which are ignored completely, and in some cases the discussion seems to be species specific, but in general the work is quite comprehensive.

Response: See responses above.

2. It may be useful to organize some of the discussion around a set of themes or topics to provide a little more structure to the discussion.

Response: Could be done later if desired.

Question 3

1. Additional topics which might be included because of their impact on the structural realignments occurring in the agricultural industry would be:

a. Supply chain/value chain approaches to the restructuring of the food production and distribution industry,

b. Value added production/investments and new age cooperatives as vehicles or strategies for producers to maintain more control in the agricultural production and distribution system,

c. Biotech driven mergers and acquisitions in the food production and distribution industries.

2. ***[The reviewer mentioned]*** a major study of the future of agriculture entitled "Food System 21: Gearing Up for a New Millennium" which may be a useful reference document for some of the questions raised here. It would be particularly useful in my judgment in strengthening the arguments with respect to the impact that consumers/food retailers/food distributors are having on the restructuring of production agriculture.

Response: We have added a brief discussion this publication.

Question 4

No additional comments.

Reviewer #3

Date sent: *Tue, 15 Jun 1999 08:29:02 -0500*

To: *wlazarus@extension.umn.edu*

From: *[Reviewer #3]*

Subject: *review*

Bill:

I have attached a copy of some page by page comments. It is a Word file, I can send something else if you need it. I just realized that you gave me an 'official' response sheet. Most of the items are covered in the attachment but if you need them here goes.

1. I think you have done a nice job summarizing what is a very complex subject. There are a couple of items that were not mentioned that I think deserve some mention. The environmental costs associated with the larger units are one of the major concerns and even if that aspect is mentioned elsewhere in the report, I think that it would be important to mention here. There should be more discussion of the impact of the "L" shape cost curve. You mention it but the fact that farms are getting bigger to generate an income is often confused with farms continuing to get bigger due to efficiency. There are initial economies of size but farms are exceeding that point now due to the income considerations. Finally, in the marketing section, there should be more discussion of the impact of contracting with near monopolists and the impact of concentration throughout the food system. Dr. Harl and Dr. Heffernan would be some sources to include in the literature review.

Response: Added Harl reference and quite a bit of other material on contracting.

This is presented in a clear manner and a good summary of the material.

2. With the exceptions noted in 1) above I think you did a good job addressing the GEIS document. I found it somewhat confusing the different questions and moving them around but I am sure that you will sort all that out.

3. I don't know the entire GEIS report but there are several factors that need to be addressed in addition to what you have covered. I discussed some of them in the further research section of my comments. Market access is a major producer complaint that I hear. It is one thing to be a monopolist and it is another to be able to act like one. I also would like to see the whole issue of a competitive market more thoroughly discussed. Many people call for a competitive market but they don't want to see everything that encompasses a free market, i.e., open pricing, complete information for everyone in the market and so forth. It is a bit like the cartoon where the man says 'I need to be a monopolist so I can compete'. We need a better understanding of what this means and its effect. I also think that the use of more innovative government programs need to be explored.

Bill, please let me know if this is not what you want or needed. Also, let me know if there is anything you don't understand.

I hope that this helped. Please let me know when this would be available for citation.

[Attachment]

I am going to give some specific comments and a few general ones. I also am going to include a few typos, etc. that I noticed.

Pg. 1: the last bullet is somewhat confusing, mixing land, sales, occupation all in one sentence.

This statement was clarified to reflect relationships between operator characteristics with gross sales and land base. This section will be updated with 1997 Agricultural Census data if time permits.

Pg. 2: typo in the last sentence

Correction made

Pg. 3: why not include an all farms row in the table? This would be useful information in making the comparison

Response: Added all farms row.

Pg. 6: Given that this is for lay people with diverse backgrounds you might want to explain what a "Lester classification" is.

Response: Mo-Abdalla did not really explain it, and time does not permit checking it out at this time – something for future work.

Pg. 7: There are several places where the sentence starts with the pronoun I, I have often heard or I am not aware, if these are quotes from Drabenstott then they should be noted. If they are not quotes then I would rephrase them

Response: Corrected.

Pg. 9: Why is OLSON all capital letters?

Response: No reason. Copied from a web page in that form. Should be corrected later as time permits.

Pg. 10: I do not think that "Stay in" is a very good measure of costs of production. I realize that this study used this and you use what is available but I think that you need to add some stronger disclaimers regarding its use. There are many factors that influence whether or not a producer "stays in"

Response: Added a stronger disclaimer.

I really think that this is the place to bring in the whole discussion of income versus efficiency. You touch on this issue on page 36 when you say "the most significant issue is to market enough milk to generate the desired level of family income". I feel that this is a key notion that is often overlooked. The L shaped average cost curve you mentioned is exhibited in all of the studies of the Iowa Farm Business data that I have done. This is an important point for two reasons. First, many people assume that the larger units are needed for efficiency and that to keep the costs of food low farms have to be big. Second, the current production techniques we employ narrow the profit margin for the farm. They are getting

bigger for the income not to lower costs of production. Realizing this opens more options for the farmer and society to pursue if the increase in size is for income not efficiency.

Response: Added quite a bit of additional discussion of the L shaped cost curve and economies of size issues.

Pg. 12: You do mention the above at the bottom by saying "...maintain family income by expanding." Expansion is one option but there are others.

Response: He is correct that there may be other options for maintaining family income, but this section dealt only with the economies of size issue and it seems beyond the scope of the question to go into other options in detail.

Pg. 14: sixth line of the text, there is the word Table missing from in front of 15.

Response: Fixed

Pg. 17: last full sentence reads odd. I think there is an extra contributing net farm income in it

This sentence was corrected and clarified.

Pg. 18: First two full paragraphs seem contradictory in their tone

Clarification was made on the findings those more capital-intensive parlors in non-traditional dairies are less profitable than less capital-intensive parlors.

Pg. 20: Under profitability it talks about the return "per operator". That seems strange to me. Does that imply that there is more than one operator of the farm, is it the same as worker? Usually you think of operator in the sense of owner/operator.

The definition of per operator/manager was provided for clarification.

Pg. 26: The headings are off and it is really confusing

Response: Adjusted the headings.

I was confused with the numbers from the different Tables. Where did the numbers for Table 13 come from? If I am reading it correct both Table 10 and 13 come from the MN Farm Business summary. However, in Table 10 there are 161 farms in the top 20% with an average herd size of 73. In Table 13 there are 565 farms with <100 cows. This seems like there are two different data sets being used or something. It might be worth putting a little more description of the data sets and why the number of farms and the results are so different. This gets further confusing when you look at the figures presented by Jackson later on in the review.

Response: Tables 10 and 13 related to two different time periods – 1996 and 1998. The changes show how the financial conditions have changed. This has been clarified as the tables are discussed.

One whole aspect that I found missing from this discussion was the issue of external costs especially as they relate to manure. The increasing size of operations has led to increasing problems for air and water quality. These costs increase as the concentration of animals increases. This is evident in Iowa where the State has almost the same number of swine as it did 15 years ago but with a tremendous increase in the problems associated with their production. There are many reasons for this increase in complaints but one of the reasons is the increased concentration of animals per unit.

Response: Should be covered in Topic F on external costs, by Carl Phillips.

Question E2. I appreciate the difficulty in trying to reduce this question to just a few pages. However, I would have liked to see a bit broader discussion of some of the issues. The overall issues of concentration in the packing industry are a major concern to some. Neil Harl and Bill Heffernun a University of Missouri Rural Sociologist present some interesting discussion regarding the impact of contracting with a near monopolist and the concentration that is spreading throughout the entire food system. The whole nature of farming and the food system is changing and the direction of that change and its impact need to be fully discussed. The questions of captive supply, bundling of inputs, and market access are just a few of the more serious issues that warrant attention.

Response: Added Harl as well as Strange-Higby and Land Stewardship to strengthen this section.

Pg. 32 fourth line of first full paragraph, typo; first line of third full paragraph, typo.

Response: Corrected.

There is a NC regional Extension task force looking into alternative swine production systems.

Response: Added citation.

For future research I think that it is important to look at options and alternatives that may be available. I think it is important to discuss and further understand the consumer segmenting and the opportunities that will provide. I think it is important to have a better understanding of what is happening to rural communities and the environment and to try to figure some way to include these costs and benefits into the decision making. Finally, one thing that is not mentioned often is the impact of higher energy prices. Our system is predicated on cheap energy. A change in this situation could cause differences to develop.

Response: Added discussion under critique of questions as well as under suggested new research.

Reviewer #4

EXTERNAL REVIEWER FORM

State of Minnesota Animal Agriculture Generic Environmental Impact Statement (GEIS) Literature Review

Economic Topic II E, Profitability and Economic Viability

1) General comments on the report (i.e., is the information and data in the document complete, accurate, and understandable.

The literature review was relatively complete and well written. While I have raised questions or made suggestions in this review and in the margins of the text, they are not meant to discredit the great amount of effort that has gone into the materials I received. It is also possible that some of my concerns are addressed in other sections of the over all report. Below, I have listed some specific questions or suggestions.

"L-Shaped" cost curve
I think that this principle deserves more discussion in the report. The research is pretty strong in support of an L-shaped cost curve in agriculture and the implications are important in understanding much of the structural debate in agriculture today. It explains why farms get larger even if there is no cost per unit advantage. There are no apparent internal diseconomies of scale. If the return is $5/unit on 1000 units and the same on 100,000 units why not get larger.

It also explains much of the farm record data that is reported in this review that shows only modest returns to scale between small farms and medium-sized farms. It could be argued that there is no significant difference in size of the operations in the data sets presented. As is reported, good data for large farms is difficult to come by. Because of the wide variation in cost of production in the farms represented, it can be and is argued that there are no economies of size (most efficient v. large farms) and that there are economies of size (least efficient v. large farms).

Response: We expanded the discussion of the "L" shaped cost curve.

Presentation of Minnesota data
It would be helpful to present the share of US inventories in Minnesota along with the actual inventories and changes in inventories. A drop in Minnesota inventory may be less than the decline in the national herd or vice-versa.

Response: Added a table showing MN share of US inventories for each livestock and poultry species.

Discussion of the farm record data
The farm record data was presented very well. Efforts to tie the empirical data back to the other literature could help the reader follow the literature.

Response: We refined the discussion a bit, but time did not permit doing much on this.

Environmental regulations
Some discussion about the implications of federal regulations rather than state or local regulations would be useful. A single set of rules have different impacts across regions due to climatic differences. For example, runoff containment in arid regions differs from regions of higher rainfall like Minnesota. Such an analysis would also address the cost of compliance that is not included in the literature review.
Some discussion of the planned federal EPA policies would also be useful. Is Minnesota, with its current regulations in a better or worse position than other states when the EPA rules take effect? There were two Organized Symposium at the 1995 AAEA annual meetings that addressed livestock, environment, and structural change and some of the papers discussed state level environmental policy scores.

Response: (check on those symposia). Drabenstott discusses this point, but Mo-Abdalla is the only empirical study we could find on the impacts. This needs to be coordinated with the "Role of Government" group.

Page 28, Assumption about marketing contracts.
I agree that packer will compete, however, I question the other two assumptions. 1) *Retail prices are constant:* Through contracts and vertical coordination a processor may/will be able to differentiate their product because they have greater control over the production process. By doing so they will be able to develop the brand and price is above commodity pork from hogs purchased on the open market. Thus, retail prices may be endogenous. 2) *Packers will pass processing savings back to producers:* I believe there is some economic literature that says that the division of any savings in the farm-to-retail margin will be shared according to the relative elasticity of demand between the participants. That is to say that retailers and consumers benefit from cost savings by packers. Likewise, packers may be able to retain some of the savings for their stockholders.

Response: Those two assumptions are the ones the cited study authors made, so we reported what they did. We have added a comment about the elasticities. We are not sure what specific publications he is referring to about how retailers, consumers, and packers split the savings, and whether they are empirical studies or just theories.

Page 29, Return to contract growers.
There should be discussion about what the returns to contract growers (poultry or pork) represent relative to "independent producers." Contract growers provide a facility (a capital investment) and labor. They are not managers or risk takers. They are entitled to a return on equity and a wage, but not a return to management or a risk premium. Independent producers provide capital, labor, and management, stand the risk, and are entitled to returns to all these factors of production. The comparison of returns to hog producers in 1997 and 1998 illustrates this point very well, but the authors do not help the reader reach a conclusion about the appropriate risk premium for the amount of risk taken. The risk-adjusted income of independent producers may be well below that of contract growers.

Response: (will flesh out that discussion a bit.)

2) Did the document adequately address the original questions presented in the GEIS Scoping document?

Dairy analysis:
There is more complete production and financial record information on dairies than hogs. As mentioned above, much of the information examined clearly illustrates the differences across farms, but does little to explain issues of economies of size. It does, however, illustrate the challenges of doing economies of size research. For a given size of operation there is a very wide difference in cost of production. Thus, the "L-shaped" cost curve has a very thick line.

In many cases the dairy analysis is presentations and proceedings by Conlin. While excellent teaching materials for producers facing these questions, some of the discussion read more like a lecture than a literature review. Some conformation of the points made by other researchers would add to the presentation. In some cases, particularly pages 38-39, though interesting, I question if it addresses the questions asked.

This is now treated as a Discussion and Interpretation by the author with some changes and has been moved within the manuscript to for better flow of ideas.

3) Is there additional information that should be gathered or additional questions that should be posed and answered to address this topic issue for the animal agriculture GEIS?

Minnesota Policies
I believe that a summary of common business forms used in modern agriculture complete with advantages and disadvantages would be useful to the readers. The discussion should identify which are not available in Minnesota but are used in other states. This more complete analysis would allow readers to determine if the advantage of a given legal entity is available in another business form in Minnesota or if it is restricting the types of operations it was intended to limit.

I have seen a review of corporate farming laws by state. I believe that it was prepared by Neil Harl, although Neil Hamilton may also have such a review.

Response: That is in the "structure" topic. This reviewer was only asked to review the "profitability" topic.

Considering this report deals with the economics of the environment I would expect to see discussion on the cost of compliance. I would also like to see discussion of the implications for the beef industry. There are nearly as many farms with cattle on feed as there are farms with hogs and 60 percent more with beef cows than dairy cows. Policies targeted at expanding dairy and hog farms may have unexpected consequences for beef producers.

Response: "Cost of compliance" is an interesting question, but we were unable to find any published research on the cost of compliance in Minnesota. The study question asked specifically about Minnesota. (need to check Outlaw et al.)
Production and Marketing contracts

Lawrence, Grims and Hayenga that is cited has an updated (1997) estimate of the share of US pork production under production and marketing contracts. This survey reports the advantages and disadvantages of contracts indicated by those with contracts and those without contracts. Grimes released marketing contract numbers for January 1999 in early March. I think that some discussion framing the concerns and motivations for production and/or marketing contracts may be helpful to the reader. The research addressing these issues will make more sense.

Response: We expanded this discussion a bit. If we had more time, we could expand the discussion of concerns and motivations, but they are probably pretty well understood already so we have not put as high a priority on this as on some other issues.

4) Additional comments.

Table numbers do not match the text.

Be aware that many of the "research" projects on facility design, sustainability, and other non-traditional production systems are often demonstrations with observations of one and degrees of freedom of zero. While useful as a teaching or promotion tool they are not oriented to deliver research results.

Response: Table numbers should be fixed now. We agree with the caution about demonstration-type projects. As far as we know, we have not said anything in the review that would mislead readers about the usefulness of data from demonstration projects.

Reviewer #5

Comments of [Reviewer #5] on GEIS Economic Topic IID, Industry Structure and Competitiveness

General Comments on the Report

Given the time constraints and the scope of the material sent to me, I am limiting my comments to those areas where I might quickly provide some assistance. My comments are mostly related to question D4 and in limited fashion to D1, D2, D5 and D6.

Page 11. The statement on page 11 that because spot market sales accounted for 36 percent of sales and formula price contracts tied to the spot market accounted for 44 percent of sales "the spot market determined prices for 80 percent of hogs which is down only slightly from the 82.5 percent found in the 1997 survey" seems to mislead about the nature of the concern expressed by many economists (not to mention producers) about thin markets. Not everyone can be priced off the spot market – else there would be no spot market. Moreover, the thinner the market, the more likely that inferior livestock are in the spot market (a condition you say exists, although you provide no supporting evidence, see p. 42 of your text), providing a discounted basis for formula priced livestock. No matter who is underpaid for the quality of their animals, the thin market is an enemy of competition and efficiency because it distorts market signals and frustrates price discovery. Unless these issues are addressed elsewhere in the report (in which a reference to that section on page 11 would be helpful), they should be indicated here. As it stands, this section makes it sound as if a consensus exists that formula livestock are as good for competition as spot market livestock, and that is far from an accurate description of either the scientific or the political mindscape.

Response: This comment illustrates the complexity of the contract issue. As far as we can determine, the publication we cited was referring to the fact that the formula price contracts gave their contractee producers prices that tracked the spot prices as opposed to contracts that pay enhanced prices when spot market prices are low (offset by lower-than-spot prices when the spot prices are high). We believe that is an accurate description of the short-run situation (a time frame of, perhaps, a few months). The reviewer is probably accurate in expressing concern about contracts causing thinner markets, as we discussed on in section D4f (on p. 42 of the reviewer's copy). We have added a note on page 11 directing readers to the later discussion. Where he asks for supporting evidence on p. 42, the main sources of supporting evidence that we are aware of are the literature discussed in Azzam-Anderson and the following few paragraphs

The document does not adequately address the range of issues related to thin markets, including those associated with independent producers who are relegated to "residual supplier" status. This includes a shortened marketing "window" in which livestock are only purchased on certain days of the week.

Response: We added citations to a Land Stewardship Project publication which documents recent experiences that Minnesota hog producers have had with packers no longer being willing to accept hogs the same day as the producers call to make the sale.

Page 12: Competitiveness: A general comment. Having served as an expert witness in a lawsuit against a mega hog producers and having had access to the records of that company, which is loudly touted as an exemplar of cost efficiency, I can tell you that no one in the public sector has reliable

information about the cost of production of these large operations and that declarations about economies of scale and cost competitiveness are worthless. They are probably much less efficient than accepted under the conventional wisdom of even the skeptical economists. They unquestionably have market power and get premiums far in excess of any cost-related factor alone. The packers so fear an empty kill floor that they will pay dearly to sew up supply from large producers. This fear transcends temporary excess supply conditions because the packers are certain that the large producers will outlast the small, and it is exactly that situation – a concentrated supply market – that drives their desire to assure adequate supplies in the future. These issues should get mention. It might take the subpoena power of Congress to get the data you need to adequately address the issue of competitiveness in this environment.

Response: We have added a stronger caution about using the "stay in" prices that hog producers of different sizes say they need to stay in business. Still, that is the best information we have available to us. Unfortunately, the "mega hog producer" records he mentions are not public information that we have access to. He does make an interesting comment about cost of an empty kill floor. We have added some discussion about the need for additional research on how slaughter plant operating cost/unit increases when operating below or above optimal rates, which would help policy makers to judge whether quantity or long term contract premiums paid to large producers to provide animals on a more predictable schedule would be "reasonable" under Packers and Stockyards Act rules.

Page 26: State corporate farming regulation. The 35 states responding to Edelman's survey of state regulations were clearly a biased sample. A lot more than five states restrict corporate farming. Dave Aiken at University of Nebraska published a compete review of the legislation in each state based on his own survey of the statutes. That is a far better source than the Edelman survey. Maybe those state officials who responded to Edelman were only editorializing the effectiveness of their efforts to regulate corporate farms when they reported no regulation.

Response: We have revised and expanded this section based on the best information we have available.

Page 27. Somewhere in this analysis of Minnesota's law you should point out that the requirement that shareholder of corporate farm live on or "actively operate" the farm is pretty lax. You can live in your penthouse in Houston and actively operate your farm in Minnesota. This language is what distinguished Minnesota from, for example, Nebraska, which requires day-to-day labor and management.

Response: We have highlighted the difference in Minnesota's and Nebraska's laws – the phrase "day-to-day." We are not aware of any literature that actually documents how much practical difference that phrase has actually made in the directions of the livestock industries in the two states.

Page 30. The Nebraska description is technically wrong. It prohibits corporations from engaging in farming and ranching (the description makes it sound like the restriction is only against ownership of land that is engaged in farming or ranching). The wording of the exemption for poultry production is awkward. It should be clarified that it is exempt, not prohibited. To make the Nebraska description complete, you should indicate that Nebraska specifically defines the terms farming or ranching to include the "ownership, keeping, or feeding" of livestock, which brings many forms of vertical integration under the restrictions. It also has no exemption for cooperatives. It's much more restrictive than Minnesota.

Response: We have made the changes mentioned.

Page 30. The discussion evidences the bias of economists in favor of unfettered markets. Why should Midwest State limitations be consistent? Why do the differences from state-to-state need to be explained? These are sovereign actions by autonomous legislative bodies (and in some cases, by the voters) operating well within the covenants of our federal constitution (according to the US Supreme Court decisions and the federal circuit appeals court sitting in Minnesota). If Nebraska wants to restrict corporate farming more than Minnesota, that's for Nebraska to decide. Only protagonists for the corporate farms complain about this because they know that uniformity will lead to the lowest common denominator of regulation. Your inference that there is some inherent virtue in interstate consistency will be viewed, as it should, as a bias in favor of corporate farming.

Response: All we said was that the rationales for the differences were unclear, and as far as we can tell, they are. We don't feel that our wording infers any "inherent virtue" to consistency (or the lack of it).

Page 31. I don't understand the context of the discussion about multi-family operations. Is it that corporate farming laws prohibit multi-family operations because such operations cannot proceed without incorporating? That is not so, of course.

Response: Added several sentences explaining how the topic of multi-family operations relates to question D1b on interdependent vs. independent operation.

Page 37. Consumers may say they want lean pork, but when they are given a taste test (see NPPC's check-off funded survey of consumer preferences) they say they like to eat pork with good lipid (intramuscular fat) – I think the good old outdoor, northern hog favorite, the Berkshire, actually scored highest, if my memory serves me.

Response: (Add citation to NPPC survey)

Page 37. I do not know of any verifiable evidence or research that "improved" packaging improves quality or ever enhances food safety. These are merely the self-serving assertions of food retailers, aren't they?

Response: Removed the phrase about quality and food safety. As far as we can tell, the important thing for producers is how the changes in food retailing are affecting demand for farm products. Whether retailers are making those changes to improve quality or food safety, or for some other reason, is less important than the fact that they are making those changes.

There is also no evidence I know of that consumers prefer uniformity. To the contrary, by the definition of a market economy, what consumers prefer is choice. Some like fat, some like lean. As far as we know, neither Jack Sprat nor his wife liked shoe leather, or PSE pork. You are parroting the industry's incantation that mega hog production means ***uniformly better quality***, and this is just political and commercial propaganda, not science.

Response: I don't believe we said that mega hog production means uniformly better quality.

Page 40. Azzam's argument about innovation is disingenuous. He fails to note that the innovations he fawns over as a substitute for price competition came from companies who now dominate the packing industry but whose entry was facilitated by effective government regulation of competition – the consent order restricting the market power of the big five packers. Innovation usually comes from the periphery, but the periphery is only energized if you have no barriers to entry, restraints on market power, and price discovery systems that breed competition. IBP may have hit a triple with boxed beef (which, by the way,

it did not originate) but to get a good pitch to hit it needed an umpire to call balls and strikes against the big five. Unfortunately, once IBP got ahead in the game, the umpire went home (and is now being accused of fostering "static" competition by economists who have never faced a market in their lives). I apologize for being so tart, but I don't understand why economists are so quick to abandon the principles they claim as their discipline whenever it is useful in denying that free markets just don't work without some regulation of market power, which even Adam Smith recognized as an inherent evil.

Response: (planning to expand that discussion)

Page 41. If you can't address concentration and its effect on performance, why bother with the whole section on structure and competitiveness? One of the principal conclusions of the USDA Advisory Committee on Agricultural Concentration was that market power at one level of the market tends to beget market power at another level of the market. The structure, conduct, and performance of packers affects producer concentration, and both are affected by the structure, conduct, and performance of the retail supermarket industry. And although this is a Minnesota GEIS, you suggest several state policies which address this issue and there is one other: a state law that allows producers to sue retailers for anti-trust damages (something they have been proscribed from doing under court decisions, see especially the Illinois Brick case). For more on this and the literature on the market power of the retail food stores and their relationship with packers, see Strange and Higby, From the Carcass to the Kitchen, published by the Center for Rural Affairs, Walthill, Nebraska, (tel. 402.846.5428).

Response: The policy recommendations from Strange and Higby have been included.

The bottom line: It is not concentration alone, but the layering of concentrated sectors that operate as bilateral monopolies, combined with tools of vertical integration that serve as conduits for the market power at all levels to be exercised against whomever in the system has the least market power (is most competitive) – in this case, farmers. The bad drives out the good in concentrated market economies where preservation of competition is not an object of public policy.

Response: That message, without the value-laden "bad" and "good" terms, comes through several places in our report, in Heffernan and also in the Purdue publication "Food System 21" which we have added.

Page 42. Why do you tread so lightly on a premium of $0.85 cwt.? Sounds like a lot to me, and if it encourages price-depressing expansion, I bet the premium increases (the price differentiation widens). The more contracts insulate large producers relative to others from the effects of their own market expansion, the larger the price elasticity of the spot market – which you note on p. 43.

Response: We will leave it to readers to decide whether $0.85/cwt is a lot, or not.

Page 43. I am not qualified to comment on your conclusion that dairy reforms help assure farmers a fair price and consumers an abundant affordable supply of milk, but it sounds like more assertion than fact.

Response: (check wording in Bailey 1999. Maybe should say "stated purpose is ...)

Page 45. Farmers' rate of return on equity needs to include capital gain on farmland, which is the residual claimant of profit. Sad to say, they do live poor and die rich, if they can afford to live poor that long. You can't talk about terms of trade and parity if you ignore capital values. It's too big a part of the farm economy, not just in terms of farmer well-being, but in terms of competitive dynamic.

Response: Wording has been added to clarify the point that the rates shown are accrual measures based on market value balance sheets, so should include estimated unrealized capital gains. Of course, actual realized capital gains are never known until the assets are sold.

Did the document adequately address the original question in the GEIS Scoping document?

I did not receive the scoping document, so I cannot answer this question.

Response: The original questions in the scoping document were duplicated in the paper, so he had them, but perhaps didn't realize that. I also gave him the web site of the scoping document itself, so he could have checked it if he so desired.

Is there additional information that should be gathered or additional questions that should be posed and answered to address this topic issues for the animal agriculture GEIA?

Noted above, I'm afraid.

Additional Comments

I'm not sure you succeeded in the goal of writing in language that is friendly to non-economists. It's a tough task.

I assume that if reviewers names are used in connection with the eventual release of this report the usual caveats that separate the reviewers from the conclusions of the report will be included.

Reviewer #6

EXTERNAL REVIEWER FORM

State of Minnesota Animal Agriculture Generic Environmental Impact Statement (GEIS) Literature Review

Economic Topic II E, Profitability and Economic Viability

1) General comments on the report (i.e., is the information and data in the document complete, accurate, and understandable.

Overall, the reports is very thorough, concise and understandable for most individuals reasonably familiar with agriculture. Many reliable sources were used which tended to complement the material and add to the credibility.

Regarding profitability issues, the report focused primarily on revenues per unit and costs per unit, especially as they relate to economies of scale and size. In finance, profitability is ultimately measured by return or equity and return or assets. In order to measure and understand the dynamics of ROE and ROA, information on asset turnover, profit margin and leverage is needed. In other words,

ASSET TURNOVER x PROFIT MARGIN x LEVERAGE = ROE

and

ASSET TURNOVER x OPERATING PROFIT MARGIN = ROA

The report focused primarily on profit margin issues and on revenues and costs but could have focused more on asset turnover and leverage to further enhance understanding profitability. Understanding these issues is important in assessing why producers continue to invest when profit margins continue to narrow.

Response: The text we have added on the L-shaped cost curve and industrialization address this at least in part. While he is correct on the importance of asset turnover and leverage, we don't have the time to address it in very much depth at this point.

2) Did the document adequately address the original questions presented in the GEIS Scoping document?

Generally yes. although, the report could have included more information on the potential economic gains provided by production technology now available in agriculture. For example, in pork production, technology such as all in fall out pig flow, segregated early weaning, phase feeding and artificial insemination are now widely used. Some economies of scale and size are needed to optimize these technologies but they all are having dramatic impacts on profitability, viability, ownership and control.

Response: Addressed in the new "Industrialization of the Swine Industry" section.

3) Is there additional information that should be gathered or additional questions that should be posed and answered to address this topic issues for the animal agriculture GEIS?

Most key questions were asked and appropriately answered. The following questions would also be complimentary to the report.

- What is the optimal size and scale needed to fully exploit the production technology available in the respective industries.

- What characteristics of an operation provide for optimization of financial leverage and cost of capital.

- Of vertical integration, vertical coordination or traditional fragmented commodity buyer and seller, which provide the optimal system in maximizing long term profitability.

Response: Again, this is addressed at least in part in the industrialization material. The published material on these three questions tends to be more of the "expert opinion" rather than empirically tested relationships, which makes us a little uncomfortable speculating on specifics such as optimal size.

4) Additional comments.

Separate reports are needed for each agricultural industry studied. For example, separate reports are needed for hogs and dairy. These industries have some parallels but the report could be more revealing and useful with separate reports.

Response: Separate reports were not called for on the project, but sound like a useful way to organize the information for future use.

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External Costs and Benefits

F

Generic Environmental Impact Statement on Animal Agriculture:

A Summary of the Literature Related to External Benefits and Costs (F)

Prepared for the Minnesota Environmental Quality Board

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Executive Summary

Overview

Most of the environmental impacts discussed in the GEIS are characterized by external costs and benefits (or "externalities"). The questions in the GEIS scoping document catalog many of the sources of those externalities. This topic's report looks at how to quantify some of those externalities -- that is, attach dollar values to them. Quantification is important because just about any policy or practice will result in externalities, both positive and negative. But the question remains, *how big are they?* Are they worth worrying about?

The report is divided between community and regional economic externalities from animal agriculture (which can be both positive and negative) and other spillovers that center on pollution impact, though they cover some other areas (which are generally negative).

This report was created as two separate parts, which are largely not integrated in this draft. The first part (overview, spillover/pollution section) was prepared Phillips in collaboration with Welle and Erin Lees (graduate student, UM EOH). The second part (regional economics) was prepared by Morse and Guess-Murphy.

Spillover/Pollution Section

On the spillover/pollution side, the state of the literature can be summarized quite succinctly: The tools exist to map particular policies or practices in animal agriculture to the value of the resulting externalities, and the possibility is generally acknowledged in several related literatures. However, the actual mapping that would be of immediate use in the GEIS process has only been done a few times for a few specifics.

Technologies exist that let us estimate the effect a policy or practice will have on the environment (including ecosystems, recreation, and health). These are discussed under the other topics in the literature review, and the studies have been carried out in many areas. Technologies also exist in the field of economics to put a value on a particular level of environmental degradation, health risk, or other spillover. These valuation methods have been used in thousands of studies of many environmental impacts. The theory behind these techniques and some of the specifics that are most important to the GEIS are discussed in the report.

Unfortunately, the literature contains very few cases where previous analysis has followed the entire path from a particular practice to a physical impact to human values. While the existing research provides a good start for many estimates that would be useful for the GEIS, new secondary research is needed to fill the gaps that a literature review cannot. In many cases, this research could produce accurate estimates of valuation with relatively little work. In other cases, new research would be needed.

In terms of specific areas, there have been a few studies that specifically link changes in property values to nearby large-scale animal agriculture operations. However, these have produced mixed results and are not sufficient to provide an estimate of the magnitude of effects (or possibly even the sign). Further research in this area will likely require de novo studies, since there is little

other data that can substitute. This situation is similar for valuing the externalities related to animal well-being. People's valuations for improving agricultural animal well-being have been studied to some extent, and some numbers exist, but they are sparse.

By contrast, water quality studies have apparently not completed the link from specific practices to specific values. However, there are hundreds of studies valuing water quality externalities in terms of the quality itself or its implications for health, recreation, or ecology. Research valuing air quality provides similar information, as does research valuing of terrestrial habitats. Valuations of human morbidity and mortality have been extensively studied. These could be linked to the effects of animal agriculture, but have not been.

The use of existing studies to put values on different impacts in different places (which would be needed to apply all but one of the studies cited herein to Minnesota agriculture) is known as benefits transfer. Benefits transfers are quite doable in many cases, but are not trivial. They are not just a matter of literature review and borrowing the numbers from existing studies, an approach that can be quite misleading. In keeping with that, no numbers from existing studies are cited in this review, since they are more likely to be misleading than useful.

Recommendation for what further research is particularly promising follow from the above observations.

Regional Development Section

Focused on Facts not Value Judgements: In reviewing articles on this issue, we limited our review to those articles which focused on the establishment of the economic consequences to the community, region, or state of different types of livestock operations. Policy decisions require a combination of facts and values. While the scientific method can provide solid information on the facts, it can say nothing about what values people should use to make the final policy decisions (Barrows 1993). For example, while science can report on the economic benefits and environmental costs of a new livestock operation, the ultimate policy choice about zoning issues depends on how much local people value the economic benefits vs. environmental quality. Research on external benefits and costs, once satisfactorily completed, can tell us what the trade-offs are between different types of impacts. For example, there seems to be some evidence that larger farms provide less employment but higher earnings per worker. Research can not tell us whether we should prefer one over the other or even how much we are willing to give up of one to get the other. Benefit/cost analysis, which attempts to provide monetary values for both benefits and costs, does attempt to address these trade-offs. It is not covered in this portion of the report.

Good research depends upon using the scientific method. The scientific method includes two major features: 1) refutable hypotheses and 2) replicable research methods. First, consider refutable hypotheses. Popper argues that "science produces and tests refutable hypotheses and non-science does not. Scientific knowledge consists of the set of refutable hypotheses which have not yet been falsified" (Fox 1997). A hypothesis is a tentative explanation of facts or the

connections between two variables. A refutable hypothesis can be tested against data and shown to be false. If it is not refuted when the data is applied, then it is accepted as probably true. Second, consider replicable research methods. Researchers are trained to be highly skeptical of research done by their peers. For a scientific test to be credible the scientist must report his research methods in so much detail that another scientist could replicate the research. Naturally, if the first scientist has honestly reported his results, then the second scientist replicating the test with the same data and the same research methods should get the same results. Without a detailed description of the methods in any research report it is difficult to evaluate the quality of the research.

A second type of research involves estimation procedures using the best available knowledge together with explicit assumptions. These operation research models are not trying to discover new facts but are merely using existing knowledge in models where there are complex relationships between variables. While operations research models do not have refutable hypotheses, they share the need for clearly articulated research methods. The assumptions, the data, and the computational methods need to be clearly specified to allow an evaluation of the validity of the research. This quality of being clearly specified is often called "transparency." We have focused on articles that clearly describe their research methods and have transparency in their models.

In reviewing the literature we found some articles had flawed research methodology. In these cases, we provide a critique of the articles but often do not provide detailed summaries of their findings. To provide detailed summaries would be irresponsible since there is a tendency for some readers to focus on the findings and ignore the technical discussion of methodological errors. The final picture is not a simple average of all the literature. Rather, greater weight needs to be placed on studies that are carefully done. In contrast, we attempt to give equal emphasis to studies, regardless of their conclusions on issues. To the best of our ability, given the time constraints, however, we have cited as much of the literature as possible on these issues.

Major Findings: The following summarize the major findings of this portion of the literature review:

1) Livestock production and processing makes important contributions to the Minnesota economy (Jahae and van Staalduinen 1992; AG NOMICS Research 1992; Morse 1998; Doherty and Morse 1999).

2) None of the current research can be used to evaluate the impacts of changes in regulations or other economic shocks to the livestock industry. (Note: The introduction has a primer on terms used in this report.)

3) The data on impacts provided by the best of regional impact models can provide only partial information for public policy decisions. Additional information will be needed on the social and environmental risks and costs. Final policy decisions require value-judgements which are by nature not scientific (Barrows 1993).

4) Integrated econometric/input-output models offer the best promise for estimating the regional economic and fiscal impacts of economic shocks. However, this type of model has only been applied the pork industry in Iowa (Otto and others 1996; Otto and others 1998). A Minnesota integrated econometric/input-output model is being developed (Kennedy 1999).

5) Use of operations research models (such as input-output) requires very careful attention to the quality of the data, the specification of the nature of the economic shock, and the assumptions on regional purchase coefficients (Miller and Blair 1985; Otto and Johnson 1993; Otto and others 1998; Thompson and Haskins 1998).

6) The amount of local versus non-local spending by farmers influences the multiplier effects. The best available research (Chism 1993; Chism and Levins 1994) found that the expenditure per acre was unchanged as the size increased (but the percentage fell due to higher overall spending by large farms). If further research confirms this finding, it means that as long as the land stays in livestock production, farm size has no positive or negative impact on local economic impacts.

7) Wages appear to be competitive in the livestock industry, after controlling for skills and regional differences. However, the research base for this conclusion is very thin (Hurley and others 1996)

8) The public sector fiscal impacts of livestock operations appear to be positive. Again, the research base for this is very preliminary and needs much greater attention (Otto and others 1998).

9) Research on the impacts of farm size on poverty has used either the comparable area approach or a variation using multiple regression analysis. The most comprehensive study (Lobao and Schulman 1991) found rural poverty rates were influenced most by social relations and economic structure of the region and least by the size of farms.

10) Research on the impacts of farm size on income and employment suggests a trade-off. Larger farms yield higher incomes but fewer jobs (Marousek 1979; Otto and others 1998; Thompson and Haskins 1998).

Probably the most important finding of the literature search was that none of the Minnesota studies examined directly addressed the local economic and fiscal impacts of adding a new feedlot. The work underway by Inhyuck Ha and Diego Platas comes the closest to addressing this issue. It will be ready in December 2000.

Topics covered: The Introduction gives a primer on the terminology and methods used in regional economic analysis. Section 1 then gives a critique of the scoping document study questions. Section 2 reviews the first two (actually three are listed) questions in section II.F of the scoping document. Note that this section of the report does not deal with pollution externalities or with property taxes. Both of these are covered in the other part of this report.

There are potentially important indirect effects on the demographics of a community, the need for social services and educational programs. These are covered in section on social /community impacts. The regional economic impacts of livestock operations depend, in part, on the economic viability of these operations. These questions are covered in the sections on industry structure/ competitiveness and profitability/ economic viability. Section 3 reports on the ongoing research. Section 4 provides recommendations for additional research on the regional economic impacts of animal agriculture.

General Introduction

External benefits are at the core of much of the GEIS, which as a whole could be considered a study of the various external costs and benefits attributable to animal agriculture. It is clear that these external costs and benefits related to animal agriculture are quite large, but their total magnitude has seldom been considered. The GEIS provides a comprehensive look at the breadth of external costs and benefits, and most parts of it provide information that can be used to quantify them.

External costs and benefits, typically called "externalities" in economics, are impacts felt by people who are not party to a particular decision or transaction. For example, a farm has internalized costs (purchases of inputs) and when it sells its product there are internalized benefits (from the market transaction), but along the way there are external costs (effluent that is not paid for) and external benefits (contributing to an appreciated way of life). In economics, externalities are one of several "market failures," imperfections in the market that prevent "invisible hand" forces from leading to maximum welfare. Were it not for external costs and benefits the need for government intervention in the market would be dramatically reduced and much of the concern that led to this GEIS would not exist. Indeed, the phrase "environmental impact" in the Scoping Document is used quite broadly, almost as a synonym for the usually broader term "externalities."

Interpretation and Critique of the GEIS Scoping Document Questions

The present report was prepared based on two particular interpretations of the questions in the GEIS Scoping Document. First, the division between costs and benefits was reinterpreted to be a division between community/regional economic externalities (roughly Questions 1 and 2) and the usually negative spillovers that affect the environment and health (roughly Questions 3 and 4). This redefinition closely parallels the division between costs and benefits in the Scoping Document, but it better reflects how the literature is divided. It is also well defined; contrary to intuition, drawing a line between costs and benefits turns out to be arbitrary and basically impossible. (As a simple example of this, does a tightening of effluent regulations entail a *benefit* to the environment or is it the removal of a previously existing external *cost*? The distinction is purely semantic.) For convenience, the current report addresses environmental and health spillovers first and community/regional economic issues second. These areas are sufficiently different that the two halves of this report are largely independent of each other.

A second important interpretation of the Scoping Document is that the words "what are" in the question posed, "what are the overall economic costs/benefits?" can be interpreted to mean "list" or "how big are?" Since the Scoping Document itself provides the list, and the literature reviews from the other areas will expand on it in great detail, there is little to be gained by duplicating that here. Instead, given that the question is asked in the language of cost-benefit analysis and quantifying externalities, and is categorized in the economics sections, the present discussion focuses on attempts to quantify the externalities. These interpretations of the questions were approved by the EQB staff before this report was started.

Separate responses are also offered in each of the two major sections of the report. The specific bullet points have been reorganized to better reflect how the literature and research in these areas is organized, and this is reflected in the revised table of contents.

Real vs. Pecuniary Costs

Economists explicitly take an agnostic position on what costs and benefits in the world should be counted. Economists will attempt to measure them all, and it is up to policy makers to decide if some should not be counted. Economists do carefully categorize costs and benefits in terms of whether they are real resource costs (something is totally lost to the world) or pecuniary costs and benefits (those related to the movement of money). These areas have substantial overlap, but also substantial non-overlap.

Real resource costs are often simply called "real costs" in economics, reflecting the underlying notion in economics that for most purposes of economic analysis, these are what we should consider. These include the consumption of actual valuable resources, such as the land or labor used in a production process, capital goods that are used to produce other things people want, or the time people devote to labor. They also include someone's loss of happiness when, for example, an environmental amenity is injured, even if this does not involve any change to any financial or commercial transaction. Such costs and benefits that do not involve a change in monetary wealth or commercial transactions are often specifically identified as *non-pecuniary*. Real costs are closely related to pecuniary costs in the sense that they are often (but not always) measurable in terms of the price paid for something. The cost of labor, land, or other inputs is typically valued based on the price paid, since this should be a value that is just high enough to bid the resource away from its next-most-valuable use. The value lost from the alternative use, as reflected in the purchase price, is the real cost that accrues to society from using the resource as it is used.

More concretely, when we are interested in measuring real costs or benefits of a policy or practice by looking at the flow of money, it is critical to recognize that real costs and benefits are the *changes* in consumer or producer *surplus* (i.e., the extra benefit/profit they get from something, over and above the resources they are spending). This is a point that is somewhat subtle in the literature because it is so much a part of the bedrock of economics that it is seldom explicitly mentioned, though it is always implicit and can be found in any introductory discussion. Not understanding this is one of the most common mistakes made in analyzing economic costs and benefits. For example, if someone spends $100 for a day of recreation that is worth $300 to him, cost of not being able to enjoy that day would not the whole $300, and is most definitely not the $100 that is his measurable expenditure (a common mistake, but this $100 is the *cost* of the trip in real lost resources, not the benefit from it) -- it is the lost $200 of surplus. Similarly, if a firm or farm earns an annual profit of x on a revenue of y and it goes out of business, the real loss is x, not y (and is most certainly not y-x, which reflects the resources that the operation used up, not the goods it created).

Expanding by example, if you are able to buy an apple for $1 and you would have paid as much as $1.40 if you had to, then by being able to make the purchase, you are better off by $.40. Thus, a new policy that banned the sale of apples would have cost you $.40. The $1 you actually spend

reflects neither real benefit nor real cost to you. Similarly, if the producer expends only $.75 to get the apple to you, then he makes a producer surplus (profit) of $.25. That is how much the policy would cost him. The other $.75 in purchase price that is no longer being exchange represents the real resource cost of getting an apple to market, and is actually a saving to society. So, adding it up, the policy saved society $.75 in real resources, but resulted in the consumer not getting $1.40 worth of benefit for a *net real resource cost* of $.65, which can be measured by looking at the $.25 loss of profit and the $.40 loss of consumer surplus.

These real costs and benefits are what is being looked at in most economic calculations. They are what is considered in the spillover/pollution section of this document. Pecuniary externalities are the primary unit of analysis for regional economics, and hence the second half of the document.

Pecuniary costs and benefit look at the movement of money. This approach is interested in prices and expenditures just because they are a good measure of real costs, but in and of themselves. Pecuniary costs and benefits include expenditures for goods and services, and sometimes are measured in such a way to include pure transfers of money from one party to another, without any goods being purchased (such as taxes). Such statistics as the gross national product (GNP) are measures of pecuniary expenditures. Policy decisions are frequently made based on pecuniary measures, and so these are likely to be very important in the current policy discussion.

It should be noted that despite the economics jargon, most pecuniary costs are real (in the colloquial sense) to someone, since someone will be making less money, even if there is no real (in the economic sense) cost. Pecuniary costs and benefits reflect changes in total expenditures, which is quite different from the real costs and benefits discussed above. A pecuniary costs will very often mean people's net well-being is lowered (but it might not), whereas a real cost is defined based on the reduction in people's well-being. An example of how this disconnect might occur include shutting down a industrial facility that was causing pollution and only making a small profit (or perhaps losing money). There is a net real benefit to society because of the shutdown, but there may be a pecuniary cost (or, since it may be impossible to tell where the freed-up capital and labor went, we may just think there is a pecuniary cost), and there will certainly be a pecuniary cost to some people, such as local suppliers to the facility. It should be noted that the authors of this report (and the broader community of economists) include economists who consistently advocate that public policy should shift its attention from pecuniary benefits to real benefits, as well as economists who study pecuniary costs and benefits.

Which Costs are External?

In a policy context like the GEIS, some costs are clearly external, affecting people who were not party to the producer-consumer transaction of making and consuming animal products. Clear externalities include injuries to unmanaged ecosystems, health effects from effluent, and increased net profits for other local businesses. These costs and benefits tend to be mixed in with certain other costs that are not so clearly external. It is fine to consider these in parallel, as long as care is taken to not add them up as if they were all externalities.

Some costs that an economist would consider to be internal (bought and paid for, as it were) are workplace injuries and depletion of soil that is owned by the same person who is depleting it. But for various reasons these are often discussed as if they are externalities. Other costs are legitimate effects of a fair market, like someone not being able to make a profit because a competitor provides a better product. Many of these non-externalities are closely associated with true externalities (like the destruction of a way of life due to market forces), but if any cost-benefit style summing up of real costs and benefits is to be done, they must be distinguished. For the measures of pecuniary costs and benefits, it may not be possible to separate the internal from the external. Such analyses are not generally set up to make such a distinction in the economic sense, but instead distinguish between inside the region and outside the region.

Local vs. Non-Local Costs

Regional economic analyses, as discussed in detail below, look at the money flowing within a particular area. A critical parameter in determining whether something is a cost, therefore, is which area. If a policy change results in a firm buying its supplies from the other side of the state rather than locally, there is a net (pecuniary) cost if the region is the county, but not if it is the state.

From a real resource perspective, this change of suppliers does not matter. However, the question of "who counts" remains. If we are only worried about the citizens of Minnesota, then the effect of Minnesota agriculture policy on many external costs (such as global warming or increases in antibiotic resistance) will not matter much since most of the net effect will be shared across the globe and most of the effect on Minnesotans will come from outside the state. Other costs will be felt disproportionately in the State, but also affect those outside (such as surface water pollution, loss of recreation areas, and foodborne diseases).

The question of where to draw the line is a political one, not scientific.

I. Spillover / Pollution Externalities

I.1 CRITIQUE OF THE SCOPING STUDY QUESTIONS

The biggest suggestions for revising the questions are contained in the general introduction, above.

The major issue within the spillover/pollution questions is the implied order of priorities. The questions ask "figure out the total cost" followed by "break these out based on distribution." After this report was researched and written, the comments of readers as well as the feeling of the authors suggest that it would have been better to look at distribution first and totals as a subsidiary point, rather than the other way around. The present prioritization led to the conclusion that the totals are uncertain, and therefore breaking the totals to reflect distribution concerns is generally not possible. A "distribution first" approach would have avoided this problem. Unfortunately, by the time this approach became clear, it was too late to carry out this major revision.

Some explicit request for a background discussion would have helped guide that presentation. This report (and most or all of the others) includes such a discussion. However, the authors had to decide exactly what and how much to provide in these "primers". Since they are clearly necessary for making sense of the information in the review, it would have been useful to have an explicit request. (The take-away lesson from this that a such a primer should be included in the prospectus for future GEIS research to the extent that it is necessary in any given area.)

Finally, for the spillover/pollution section, the specific topical subpoints are not organized in a way that reflects the literature and ease of presentation. The outline of this section has been revised from that implied by these subpoints as can be seen in the table of contents. The subpoints referred in parentheses in the table of contents refer to the original questions in the Scoping Document to indicate how we have rearranged the coverage to better fit the existing organization of the literature. The new organization covers the specific questions about external costs and benefits from the Scoping Document questions and adds a few similar points about other externalities that are addressed in the Scoping Document but were not specifically included in the externalities question. It also covers quite a lot more than the specific scoping questions.

I.2 RESPONSES TO SCOPING DOCUMENT AND RELATED QUESTIONS

Environmental and Health Externalities, Theory, Methods, and Collections of Results

To present the environmental and health externalities from animal agriculture spillovers -- roughly the "cost" half of the Scoping Document questions -- it is useful to include background on the theory of valuing environmental externalities. In some cases, we have extensive theory but relatively little empirical work. In most cases, as discussed below, we have almost no specific numbers to link to animal agriculture practices. Since this report is a literature review and not new secondary research, no attempt has been made to figure out "the right numbers" for any given externality. Indeed, no valuation numbers are presented at all because honestly interpreting the numbers from any single study typically requires pages of background and

discussion. Listing a potpourri of numbers quantifying various environmental externalities, while an easy way to write a literature review, would imply that this brief review offered more answers than it really can. The reasons for this are discussed to a greater extent under "benefits transfers," below.

Because the responses to the environmental questions are largely "it does not exist in a completed form," we have made an effort to explain what does exist in the literature and how it can be used. In many areas the major value added from this report will be presenting a picture of the existing technology that can be used to do further quantification. The presentation is intended to provide something more useful than a list of specific analyses and their highly incomplete answers they present in this area. It is intended to leave the reader with an understanding of how to think about the questions when moving forward in the GEIS process.

Why Calculate Costs and Benefits?

If there is a policy choice that is better in every way, then the decision about what to do is easy. But inevitably, there will be a tradeoff between competing claims for our scarce resources, which introduces the need for economic analysis. Often economics is incorrectly perceived to be the study of commercial transactions and goods with an explicit price (Steiner and others 1995). Indeed, economists are often among those who make this mistake. But economics is better characterized as the study of the tradeoffs of scares resources people make to try to maximize welfare. As such, it is interested in all the costs and benefits associated with a policy or decision.

In the case of animal agriculture and externalities, it is widely agreed that certain environmental impacts (almost all negative) occur. There is clearly substantial public concern, with a recent poll showing that 80% of voters favor tougher uniform standards for air and water pollution from "factory farms" and most would vote accordingly (Lake Snell Perry & Associates 1999).[1] But these observations are not sufficient knowledge for making good policy decisions, since the amount the public is (or should be) willing to pay to eliminate the externalities is not identified. To make effective decisions, it is necessary to know magnitudes.

Ideally, if we can calculate the external cost of something, we can create the incentive to produce no more than the socially optimal amount of the externality by imposing the appropriate tax rate, known as a Pigouvian tax. For a specific application to effluent from livestock, see Nuppenau et al. (1995). Even without this optimal taxation scheme, regulation requires specific valuation of externalities to get the socially optimal levels of externalities, since any regulation will have a specific quantitative effect, rather than just serving the qualitative goal of reducing something that people do not like. For an application to livestock, see Lauwers et al. (1995).

Putting values on externalities is an important part of environmental cost-benefit analysis. This method of analyzing regulation by adding up the various costs and benefits has become

[1] The study followed standard polling methods, contacting 1000 registered voters in March, 1999. The study was commissioned by ten public interest organizations including the Humane Society of the United States and Clean Water Action of Minnesota.

increasingly important in environmental policy, particularly since President Reagan issued an executive order requiring assessment of costs and benefits for major regulations. (However, many environmental regulations like the Clean Water Act and the Clean Air Act explicitly forbid comparing costs and benefits (Cropper and Oates 1992).) A detailed discussion of cost-benefit analysis is beyond the scope here (a brief discussion can be found in another recent State scoping study, coauthored by the author of this section (Tetra Tech EM Inc. and others 1998)[2]). But it is worth noting that the method has gotten a bit of an undeserved bad name in Minnesota due to several recent faulty studies that were not really true cost-benefit analyses.

There is some debate about whether to quantify externalities (or other values) if the methods are imperfect. The usual response is that as long as we are honest about the flaws in the numbers, it is better to have some numbers than none.

Valuation Methods

There is a general agreement in economics that putting a value on something is tantamount to figuring out how much it is worth to someone, which in turn is tantamount to describing what they would exchange for it. Certain costs and benefits are relatively easy to measure and identify, such as the benefits consumers get from things they buy and the profits producers make from selling them. Other benefits, such as those associated with environmental recreation or good health, are a little more difficult to measure because they are not directly tied to a market. A further class of values that are not associated with any activity or observable state of being, non-use values, are particularly difficult to measure. However, since these values -- which include the pleasure of knowing that wilderness exists or the unhappiness about an injured ecosystem -- are particularly important in environmental economics, it is necessary to find a way to measure them.

More specifically the cost that should be attributed to a negative externality is the cost of efficient mitigation action plus the cost of any residual harm (Phillips and Zeckhauser 1995). Similarly the benefit of a positive externality is the extra benefit enjoyed by the world less any additional costs incurred to realize those benefits. Quantification is a much tougher problem. Various methods have been developed, but good analysis remains difficult. Even as theory abounds and is increasingly refined, actual measurements are relatively sparse. As Klamer and McCloskey (1988, as quoted in Shabman and Stephenson, 1996) put it, "the problem in economic life is not calculating what to do after knowing all that you need to know. The problem is to know."

Smith (1997, p. 157) suggests in his review of valuing environmental resources, "market-oriented systems around the world are being forced (by growing demands) to find ways of reflecting the economic values of environmental resources available outside markets in the decisions that are made about how they are used and protected." In other words, given our decision-making processes, it is necessary to describe the value of non-marketed resources in concrete terms -- usually their dollar value. The discussion in this subsection summarizes the basic overview of

[2] Work on the watershed cost-benefit project would contribute substantially to important questions in the GEIS, but it was defunded in the current State budget.

valuation theory and methods that is found in most discussions of the subject (Smith 1997; Hannemann 1992).

Market-based externalities (such as property value impacts) can be calculated using market prices. Non-market externalities, including most environmental externalities, usually cannot. Yet some valuation must be calculated if these costs (and benefits) are going to be considered alongside more quantifiable commercial effects of an activity. When some values are considered qualitatively while others have numbers attached, the former often get forgotten and only the latter reported.

In response to this, valuation studies were first carried out in the 1950s (Hannemann 1992). There are five reasons why there has been some attempt to value environmental externalities: CBA of projects, CBA of new regulations, natural resource damage (liability) assessment, environmental costing, and environmental accounting (Navrud and Pruckner 1997). It should be noted that some of these can benefit from rough, back of the envelope, calculations while others (particularly liability (Phillips and Zeckhauser 1995)) need to be quite precise. This means that the existing literature has vastly variable levels of precision (even apart from the variably quality of the work), making it challenging to assess.

Valuation methods are typically categorized based on whether they involve actual market transactions ("revealed preference") or not (hypothetical), and whether they directly measure the value in question, or whether some further machinations must be performed to determine the value indirectly. Indirect use of revealed preference (market purchase) data is made in the hedonic price method and travel cost method, which are discussed below. The most intuitively appealing and controversial method is direct but hypothetical, and basically consists of asking people to tell us their valuations. This method (contingent valuation) is also discussed below.

Many analysts have applied multiple valuation methods to the same question to try to calibrate the methods and get better measures of the values in question. They generally show very different results (Shabman and Stephenson 1996), prompting the observation that we as a society need to decide which valuation criteria truly reflect public preferences (Carson and Navarro 1988).

Direct Use of Market Prices, including Alternative Production and Mitigation. Direct revealed measures of a value, the price that someone actually pays for something in a fair market, are the gold standard in economics. This can provide measure of certain externalities. The simplest are cases where someone can no longer buy or sell something thanks to a policy or practice of someone else. In that case, market methods can be used to estimate the loss in consumer or producer surplus.

In other cases, particularly environmental health concerns, mitigation can be purchased. For example, polluted drinking water can be processed or replaced. In that case, the price of the mitigation perfectly measures one cost of the pollution, since that expenditure is what it takes to undo the effect of the injury on drinking water quality and would not have been necessary were it not for the pollution.

A more subtle application of market methods to the costs of one source of pollution is the savings that could be achieved by allowing another polluter to relax its pollution controls by the corresponding amount. This comparison is particularly applicable for looking at the costs of relatively unregulated nonpoint sources of pollution like animal agriculture (Freeman, 1990; Shortle and Abler 1997). For example, if there is a policy that requires a city to treat wastewater to a achieve certain level of dissolved chemicals, and the cost of the treatment is known from the engineering of the treatment plant, then we know the cost that effluent from upstream agricultural sources -- it is the cost of the extra treatment by the city that could be avoided if the agricultural effluent were reduced. This approach has largely been overlooked in the literature. It would have been used in the State's cost-benefit analysis of watershed policy if it had been funded.

For most environmental externalities, however, methods other than direct use of revealed preference are needed.

Hedonic Pricing Studies. Hedonic pricing attempts to assess the price of real estate based on its characteristics, and use statistical techniques to extract the value of such things as being near a scenic waterway or an odorous facility. Using real estate prices to value environmental amenities (or disamenities) enjoyed by the user of a certain parcel of land has a long tradition and is respected as a good method (Freeman 1993; Clark and Nieves 1994; Palmquist 1991). The hedonic method works to measure localized effects that do not affect the overall market of the goods being studied (usually houses), but do affect the appeal of certain ones. This means that hedonic methods, while appealing because they use real consumer behavior, are limited because they can only value a certain class of externalities.

Hedonic studies are particularly useful for measuring externalities from locally undesirable land uses or positive environmental amenities. For example, Steinnes (1992) looked at the value of water quality in Minnesota as it affects lakeshore land values. Such a measure provides an estimate of one of the external costs attributable to water pollution.

A subtle point that should be understood about sale prices (and thus the results of hedonic studies) is that they provide a "market clearing" or "equilibrium" price. Roughly speaking this means they reflect the preferences of the person who most wants the property rather than the average person's preferences. This may explain the disconnect between large perceived impacts and smaller measured impacts that are reported for many hedonic studies. Some people might find that living next to a hog farm or a nuclear power plant is extremely unpleasant, dramatically lowering the value of a property to them, but other people may not care. As long as there are enough people in the latter category, the effect on the price will be small, regardless of the opinion of those in the former category. This might mean that hedonic studies understate the effect of a disamenity on people who own affected property and are particularly bothered by it, but are not inclined to sell for whatever reason.

Travel Cost Method. The travel cost method (TCM) provides a measure of the value of an environmental amenity that people must travel to in order to enjoy (particularly recreational sites). Technically, the cost of travel traces out a demand curve for the good, from which the net

surplus from the environmental recreation can be calculated. (For more details, see Smith (1997).) Note that the cost of travel itself is *not* the loss to consumers if the amenity is injured. The travel cost is just that -- a cost -- in the same way that the price of a good does not tell us how much benefit someone gets from being able to buy it. The net benefit is the surplus, the amount *more* than the cost that people would have paid if they had to. But the different pattern of use by people who face different travel costs allows us to estimate their net benefit, the consumer surplus. This is a particularly popular method for estimating the value of environmental recreation because it uses revealed preference data (that is, it is founded on actual behavior).

Contingent Valuation Studies. Central to the current literature on valuing environmental externalities is the contingent valuation (Phillips and Zeckhauser 1995) method. This method, which at its core consists of asking people their willingness to pay (Lareau and Rae 1989) for something, is the only method for valuing many (perhaps most) environmental impacts, because it is the only method for measuring non-use values. Notice that all the other methods discussed can only measure something that someone is physically using, either consumptively, recreationally, or aesthetically.

The CV method remains extremely controversial, and there are many observers who conclude that it cannot produce reliable results (Hausman 1993; Diamond PA and Hausman JA 1994; Diamond PA 1996).[3] However, CV was effectively given a blessing by a blue ribbon panel including highly-respected economists, conditional on certain rules being followed in applying it (Arrow K and others 1993). Everyone agrees that survey respondents have no particular incentive to give correct answers, and have some incentive to strategically give incorrect answers, but proponents of this and other survey research methods insist that it is still possible to get useful results. Most assessments also recognize that analysts must be very careful in how they conduct the survey (Smith 1997).

There are probably hundreds of CV analyses ongoing currently in the U.S. Every month there are dozens of articles from CV research in the economics literature. Due to the proliferation of articles, since 1997 contingent valuation has had its own subject code in the *Journal of Economic Literature*, a level of aggregation generally reserved for quite broad categories of subject matter. A recent special issue of *Resource and Energy Economics* (Tolley and Fabian 1998) was devoted to CV, and there have been numerous organized discussions in various other forums over the last decade. Most published articles look at environmental goods, though relatively few break out the impacts of agriculture. Most of the articles emphasize as their primary goal refining the method rather than providing a specific quantitative result (indeed, many of the titles do not even

[3] Hausman and Diamond, who top the list of critics of CV, were consultants for Exxon in the Valdez case which involved a huge valuation from CV, though this certainly does not dilute the importance of their criticisms. It should be noted that the author of this section has also been a critic of CV *as it has been applied* (Phillips and Zeckhauser 1995) and has done consulting work based on that position, but currently believes that CV is ultimately promising as a method for improving environmental decisions.

mention what was being measured). This emphasizes the current mood of uncertainty about CV results.

Very few of the existing papers provide direct measures of WTP to eliminate externalities from animal agriculture, though many of them could apply. Some recent examples of the topics studied are ecosystems on a global basis (deforestation) (Kramer and Mercer 1997), recreational canoeing (Rollins 1997), and effects of tourism on rural lifestyles (Lindberg and others 1997). Among important classic studies is the "Spotted Owl" study which was important in making Northwest forest policy (Hagen and others 1992).

CV as applied presents some major pitfalls for making policy decisions. For example, many studies attempt to measure household WTP for a certain percentage reduction in some pollution. This may be a good rough cut at measuring general public sentiment, but tells us almost nothing about the actual value of the impact of a particular industry (let alone a single regulation or facility). As another example, CV studies often ask people to implicitly make technical estimates that are better made by experts by asking them about their WTP for a change in policies or practices rather than a change in physical outcomes. CV questions are useful for determining how much a final outcome (like safe water or better vistas) is worth to people, but should not be used to ask people to guess at, e.g., the probability of groundwater nitrate contamination from a new facility. More generally, like any research method, there are lots of ways to use CV badly, and many of them can be found in published articles.

Research in the context of the GEIS is unlikely to resolve any of the controversy surrounding CV as a method. However, some best-practice application of the method could provide critical information to assess some of the major questions in the field. Since the value of a particular environmental good to a particular group of people is a very idiosyncratic thing, new studies in the context of the GEIS and Minnesota would provide new information. Benefit transfer analyses (see below) of existing CV numbers would also provide some valuable information, but individual values do not transfer from studies of different people done for different purposes nearly as well as do studies of natural science phenomena.

Catalogs of Studies

There are various reviews that look at multiple analyses of environmental values and costs of environmental injuries. These include:

- X a list of more than 2000 CV studies that had been carried out at that time (many more have been done subsequently) (Carson and others 1993),
- X TCM and hedonic studies in the US (Braden and Kolstad 1991),
- X Agricultural applications in Europe (Merlo and Puppa 1994; Dubgaard and others 1994),
- X various methods and topics in Europe (Navrud 1992; Navrud and Pruckner 1997),
- X a sortable database of results from studies of various media and countries, primarily localized studies, using various methods, at the New South Wales (Wilcox 1989) Web Site (New South Wales Environment Protection Authority 1999), including more than 200 studies from the U.S.

Navrud and Pruckner (1997) note that U.S. studies have tended to emphasize health risks for air pollution while European studies have focused on non-use values. But there has been no shortage of CV studies of non-use value in the U.S., particularly in light of the importance of non-use vales in the Spotted Owl and Exxon Valdez studies.

Benefits Transfer, The Key to Most Policy Applications

Making the most of valuation data requires taking information from one study and applying it to other contexts, a technique known as *benefits transfer* (Desvousges and others 1992). U.S. EPA's desire for more numbers has resulted in a large number of benefits transfer analyses (Navrud and Pruckner 1997). It is likely that most of the time when valuation studies are used in policy making, there are benefits transfers. However, it is difficult to identify policy applications being made at various levels when they involve informal (and never published) benefits transfers.

Effective benefits transfer involves many of the same challenges as designing a good *de novo* study, and is not a trivial process. Casual analogies between one value and another are very likely to be misleading. Benefits transfer studies take the imperfect results of one study and introduce other possible sources of error, so researchers and analysts must be particularly careful not to claim unjustifiable precision or accuracy. A practical cautionary discussion about benefits transfer in state-level policy making is available at the NSW EPA Web site (1999), see both the overview and many of the detailed discussions of individual studies).

On the other hand, benefit transfers are important for policy making. It is never going to be possible to measure every value of interest, so benefits transfer should be used to expand the available information. Discussions of how to effectively do benefits transfer research can be found in Kirchhoff et al (1997), Boyle and Bergstrom (1992), Desvousges et al (1992), Feather and Hellerstein (1997), and Pearce et al. (1992).

Much of the current valuation research is so project-oriented that it badly serves the need of transferability (Smith 1997). Studies have found existing analyses to have ambiguities and arbitrary decisions that made transfers (or even comparisons) difficult (Boyle and others 1994). An important complication in transferring benefits is recognizing the relative availability of substitutes in different places. It is well known that the availability of substitutes and other mitigation opportunities (e.g., alternative water sources) will bias measurements of value unless care is taken (Hoehn 1991).

For purposes of the GEIS, benefits transfer will likely provide much valuable information and should be used. However it would be a mistake to decide ex ante (without regard to available data) that a particular value needs to be determined this way. This could easily result in the use of an inappropriate benefits transfer. Because doing effective benefits transfer of environmental values is an involved process, it is not attempted in this report. Benefits transfer requires additional careful research, not just literature review, and so specific dollar values from existing studies, values that *might* be transferable to Minnesota animal agriculture policy, are not presented in this report.

Aside: Skepticism about Valuation-Oriented Methods

Several threads in the literature -- sometimes in the non-mainstream social science literature, though more often in the natural science literature -- express deep skepticism about cost-benefit analysis or other valuation-based methods of making environmental decisions. Frequently these criticisms of the economic approach demonstrate a fundamental lack of understanding about economic methods or ignore the fact that human resources are limited and thus we need to make tradeoffs. However, some of the criticisms are more cogent. These generally focus on the problems of actually measuring costs and benefits, arguing that it is not likely to be resolved in a way that is generally accepted as accurate and so is a dead end. They conclude that alternative decision criteria are needed.

Criticisms of discussions of CV and other specific methods often overlook the fact that all valuation methods for non-market goods are imperfect and so comparisons must be made between the various imperfect methods, and between using some method versus not having a source of the data at all. These considerations apply to future research conducted under the GEIS. Neither the "fatal flaw" approach ("these methods are imperfect, so there is no use in using any of them") nor blind acceptance of the available data is appropriate.

The most substantive anti-valuation thread in the economics literature calls for "sustainability." The term has various formal definitions (Hartwick 1997), most of which are in keeping with the intuitive definition of not using resources like soil or water faster than they can be replenished. This offers a "second best" alternative to the economist's "first best" calculation of the optimal rate for depleting resources which requires the difficult calculation of the optimal trade off of gains for non-sustainable losses (Radermacher 1994). The details of this discussion are beyond the scope of the current review, but readers should be aware that this line of reasoning exists in competition with the notion that we need to focus on getting the valuations right so we can do the cost-benefit optimization.

Along the theme of sustainability, the Legislative Commission on Minnesota Resources (LCMR) recently funded a project titled "Economic Analysis of Agriculture for Multiple Benefits" for the 1999-2001 funding cycle. It contrasts with the GEIS's approach of itemizing impacts of current practices and quantifying specific externalities. Instead it looks at alternative farming systems from a perspective that is closer to the sustainability paradigm to evaluate the differing levels of economic social end environmental benefits, including the prevention of pollution, provided by various types of farming systems. The LCMR project abstract states, "The economic valuation will include crops and livestock production, other market-valued items and non-market items such as water quality, soil erosion, wildlife habitat, biodiversity, local purchases from farming operations, social capital formation, etc." The research agenda later states that it "will integrate quantification of environmental and social impacts, economic valuation and development to prevent non-point source pollution and to promote the production of multiple environmental and social benefits for society." Thus, the agenda is similar to the GEIS, but comes from a somewhat different viewpoint (one that might be called more "holistic").

Application to Animal Agriculture

Externalities from animal agriculture will have various proximate causes, including:

X production of feed grains (and the resulting use of land and other resources,

runoff, etc.),
X other resource use (beyond that needed for plant foods or integrated sustainable production methods),
X direct impact of production facilities (such as odors, leaching, and manure spills),
X direct impacts of using animals (impact on the animals, zoonoses).

Given the need for producing plants for animal agriculture, it is difficult to sort out some of the externalities of animal agriculture from those of agriculture in general. To sort out many of the impacts that are specific to animal agriculture it is necessary to determine on what portion of crop production should be attributed to animal agriculture and then calculate the impacts of that portion.

For purposes of the GEIS, an explicit decision will have to be made about whether all externalities from animal agriculture are being studied, or just those from animal agriculture *facilities* (ignoring impacts upstream in the production process), which is potentially a fairly small subset of the total. That distinction is not particularly important for the present report (since it is providing background information that would apply in either case), but will clearly be important later.

A large portion of the existing valuation studies focus on environmental goods that are associated with recreation or passive aesthetic enjoyment (e.g., vistas). This is not surprising since these are values that people are particularly concerned about, understand (and thus can price more accurately), and are associated with market decisions (travel, housing) which allows the use of multiple measurement methods. Many of these studies focus on resources that are affected by animal agriculture, particularly surface water recreation. These are addressed specifically below. Hundreds of studies look at values less relevant to the GEIS, including wilderness areas, impacts of mining, urban greenspace, urban industrial pollution, and traffic.

Costs from injury to the natural environment include damage to aquatic ecosystems (from eutrophication and water removal), damage to terrestrial ecosystems (from land use), global warming (from methane emission), acid rain (from NH_3 volatilization and NO_x deposition), and direct health impacts. Quantifying these impacts involves the dual challenge of quantifying environmental injury in the first place and determining how much of the injury is attributable to animal agriculture. Unfortunately, the implication of this challenge is that extremely little has been accomplished to date.

Quantifying the external health costs of animal agriculture (or anything else) is similar to quantifying the effects on ecosystems and other environmental goods. Some aspects of it can be calculated using observed market mechanisms, such as the cost of treating certain illnesses or the extra costs of purifying drinking water (a cost of avoiding negative health effects). Other aspects can be quantified only indirectly since they involve non-market components of human welfare. As is the case with environmental goods, the theory is relatively well developed, but actual empirical work is lacking.

Specific Responses to Scoping Document Questions

This section provides the best possible direct answers to the specific questions in the Scoping Document. It should be clearly stated at the outset that the short answer to most of these questions is "we don't know." At best it is "we don't know much." As a result of not knowing much about the big questions, we basically know nothing about the more detailed questions like how the costs vary by production method. Similarly, we can say very little about how costs are distributed other than the obvious (e.g., people living nearby or downstream/downwind feel most of the impacts, drinking water contamination is most likely to affect infants).

The Major Difficulty in Answering the Specific Questions

It is important to realize that the analysis of how an action leads to a measured cost or benefit has two distinct steps, the path from action to change in the physical world (such as an injury to an environmental good), and the path from the change in the physical world to a change in human well-being (valuation). The first step is the topic of many of the other areas of the GEIS, while this report focuses on the latter. The critical importance of the two step process is that while we have the technology to map a certain agricultural practice or policy to human welfare outcomes, it has not been done in very many cases. In many cases, someone has gone from Point A (the action) to Point B (the injury), and someone has gone from Point B' (seldom exactly the same Point B, unfortunately) to Point C (change in welfare), but no one has gone from A to C. As a result, a literature review is not sufficient to produce many values -- it can only show what groundwork has been laid to produce those values. Actually providing the values would be new research, not simply a review of the literature.

Furthermore, it is important to note that the methods used to calculate non-market valuations are quite complicated and sensitive to the exact choice of study design. As a result, care should be taken to avoid looking at a single study in an area and saying "this has been done, and the answer is X." Of course, if there is one quality study, then it does provide the best answer we have. Great care must be taken in looking at one quality study of a particular value in a particular place and transferring that to a different place or situation.

The following discussion includes many examples of valuation studies that might have some bearing on the impacts of animal agriculture, but that do not specifically study animal agriculture. These are examples selected from a huge body of literature that contains many more studies on many of these topics. It is beyond the scope of this project to completely enumerate valuation studies that might contribute *something* to valuing the impacts of animal agriculture.

Property Values / Property Tax Revenues

The environmental impacts of animal agriculture facilities as locally undesirable land uses (LULUs) include aesthetic impacts (e.g., odors, injury to surface water ecosystems) and health threats (e.g., polluted wells). These are among the easiest costs to quantify, both in theory and practice, because the costs should be incorporated into local land values -- the total monetized cost of the environmental spillover should subtract from what would otherwise be the price of the land. Economics predicts that property values (and with them, property tax revenues, which are basically just a piece of the total value that is captured by local government) will drop when negative externalities from animal agriculture operations affect residents or users of the land in

question. However, confirming this empirically and quantifying it is still a difficult task.

LULU issues and property value impacts are one of the more contentious issues in animal agriculture policy. Unlike some of the other areas of environmental impact, there are a few very specific and very talked-about papers in this area, namely Taff et al. (1996) and Palmquist et al (1997), that look at exactly the question being asked in this review. Unfortunately, these studies provide mixed results, and even if they did not, these alone would not provide nearly enough information to draw any firm conclusions.

Palmquist et al. studied residential property values near large-scale hog operations in North Carolina using the hedonic pricing method. They created an index of proximity to large operations and concentrations of manure (a variable that increases with the size of nearby operations as well as measuring the amount of nearby manure itself) and analyzed the effect on house sale prices (controlling for other characteristics of the house and property). There were 237 house sales in the study area during the study period. They found a substantial reduction in selling prices as properties are located closer to large hog facilities or as the amount of proximate manure production is increased. Signs of coefficients and estimated functional forms conformed to intuition for control and study variables. Most of the discussion focuses on odors, though there is actually nothing in the data that allows odors to be separated from other local spillovers.

Palmquist et al. could identify only one earlier study (Abeles-Allison and Conner 1990) that addressed this question. That study, in Michigan, also found a drop in property values, though it was limited to houses near facilities that been the subject of complaints, and so is particularly difficult to generalize.

Taff et al. used a similar method to study residential property sale prices in southwestern Minnesota. The study was commissioned by the Minnesota Department of Agriculture and has never been published (the cited paper is a working paper version of the report to the legislature). They examined 292 residential property sales in Renwood and Renville counties and examined the effect of a series of indicators of feedlot proximity. The indicators were discretized variables reflecting the existence of feedlots, distance to feedlots, total animal units within a certain distance, and upwind feedlots. The notorious results of the study were that they found a significant (both statistically and substantively) *increase* in property values associated with each of the measures of proximity to feedlots. The authors offer some possible explanations for what might have caused this (e.g., workers living close to facilities; houses with lowered values not coming on the market), but they were unwilling to dismiss the finding as a pure anomaly. Other possible explanations include the possibility that property values are driven up by the facilities and local economic activity (as is discussed in the second half of this report), even as they are driven down by aesthetic impacts. In any case, the best response to the controversy surrounding this report seems to be to point out that hedonic price analyses are very complicated, and like most complicated studies researchers give the best answer they can, knowing it might be wrong. The same could be said if the study had found the expected result.

It takes multiple studies and a large weight of evidence to sort out results from complicated analytic tools. These few studies do not provide nearly enough information to draw conclusions

about the impact of feedlots on property values. Whatever the findings of one or a few studies, there are still compelling reasons to believe (from anecdotal reports and intuition) that homes with odors or contaminated wells from feedlots are worth less than they would be if those impacts were eliminated (though we can construct stories of how benefits from proximate feedlot make up for this). But without useful studies, we cannot put numbers to this belief.

There is a strong history of using the hedonic price method to value the effect of other LULUs (as well as other things affecting property values) and this could inform further research on this topic. There have been attempts to measure the disutility from odors in non-agricultural settings (Lareau and Rae 1989). Various studies exist that examine house prices near non-agricultural LULUs, including landfills (Hirshfeld and others 1992; Nelson and others 1992), closed landfills (Halstead and others 1997), airports (Nelson 1980), nuclear reactors and radioactive waste disposal (Gamble and Downing 1982; Payne and others 1987), and hazardous waste sites (Ketkar 1992; Smith and Desvouges 1986). Many of these studies have found the expected results, though many do not, and the results are not always dramatic.

There is also a substantial literature that uses hedonic property value methods to value air pollution more generally (Giannias 1989; Harrison and Rubinfield 1978).

Impacts on Other Producers

One of the easiest (though not necessarily easy) externalities of pollution to estimate is the impact on downstream producers. As discussed above, the measure of the externality should be the sum of the lost consumer and producer surplus.

In the case of animal agriculture, this is particularly relevant to water pollution affecting irrigation and commercial fishing, and requiring greater purification for downstream industrial uses. We can consider purification of drinking water supplies as downstream production also. Other impacts on production, such as the long-term implications for soil nutrients are sometimes considered externalities, though these impacts are largely internal to the land owner so it is difficult (and beyond the present scope) to figure out how to address these. The impact on producers can be measured in terms of lost profit, extra expenditure, or the cost of avoiding the problem (sometimes called "averting behavior" (Smith and Desvouges 1986)).

Studies that attempt to value the impact of agriculture (not specifically animal agriculture) on downstream production include:

- X the effect of river salinity on irrigation (Lee and Howitt 1996),
- X effects of soil erosion on water treatment and other uses (Clark 1985),
- X avoidance cost for groundwater pollution (Abdalla 1994; Abdalla 1990; Abdalla and others 1992; Collins and Steinbeck 1993; Nielsen and Lee 1987; Powell 1991).

If the direct cost of eliminating an environmental externality (mitigation cost) can be determined, and such costs are indeed being paid to eliminate the impact, then that cost is the cost of the impact. A CV survey in England to find WTP for lowering drinking water nitrate produced high values that exceeded the costs of installing treatment (Hanley 1990), suggesting that the

mitigation is the right measure of cost (and the right policy response). Smearman et al. (1997) used mitigation to measure the external costs of aquaculture. Partial cost-benefit analyses are often done comparing the cost of eliminating the source of an environmental injury to the cost of remediating the injury. This is a legitimate quantification as long as those two options are interchangeable (the remediation is perfect) and the third option of just allowing the pollution to happen is not considered. (Things become much more difficult if there is a cost, but it is deemed to be less than the cost of mitigation so the mitigation is not actually done.)

As with most of the other areas of environmental impact, there do not appear to be any studies that look at the path from a particular animal agricultural practice, to environmental injury, to impact on a producer, and then from there to lost surplus. Several of the above cited studies look at the steps from injuries that can be generally traced to animal agriculture to cost of impact (in a particular place, at a particular time).

Drinking Water Quality

If drinking water pollution is not mitigated then the externality is manifested as lowered water quality. The best way to value untreated drinking water (ground or surface) contamination by animal agriculture is to return to the multi-step method described above and anchor the measure in a scientific estimate of the morbidity and mortality that is expected, with separate measures for aesthetic impacts. To our knowledge, this step-by-step linking has never been done for animal agriculture impacts, though each individual step has. For example, the link from animal agriculture to nitrate pollution is fairly clearly mapped, the link from the nitrates to methemoglobinaemia in infants is well understood, and the costs of morbidity in children has been estimated in the health literature. However, since the share of the exposure attributable to animal agriculture is difficult to determine, let alone the differential share attributable to different sectors or practices, establishing a precise value would require some new arrangement of existing knowledge.

Benefits of groundwater protection have been widely studied and valued (Segerson 1994; Boyle and others 1994). Many attempts have been made to directly measure people's valuation for drinking water quality, such as eliminating nitrates or heavy metal contamination, rather than doing the step-by-step linkage (Edwards 1988; du Vair and Loomis 1993; Hanley 1990; Jordan and Elnagheeb 1993; Schultz and Lindsay 1990). These approaches are (in the opinion of this author) highly suspect because they call upon people to make complicated technical assessments of matters they likely do not understand. Economics teaches us that people's opinions about how costly it is to be sick define that cost, but their opinions about how likely they are to become sick are not necessarily useful. In cases where the CV method is used, these studies represent a particularly tenuous use of a method that already has many possible sources of error.

An alternative method for measuring drinking water contamination is the cost of mitigating the impact (see the discussion of effects on production, above). This has been done for pollutants that are attributed to animal agriculture, though the link to particular animal agriculture sources has not been specifically calculated (Clark 1985; Harrington and others 1989).

Surface Water -- Recreation, Ecosystems, and Drinking

Animal agriculture has a substantial impact on surface water recreation, particularly angling but also boating, swimming, and aesthetic uses (vistas and odors at land recreation areas). It also affects aquatic ecosystems through effluent and water consumption. In some cases, estimates of the use values and the non-use values regarding ecosystems can be separately measured (particularly by using TCM to measure the use values and CV to measure the non-use), but in many cases they cannot, so they are addressed together (using CV studies designed to pick up both).

There are a large number of valuation studies of water usage. Some of these include environmental injuries that can be specifically linked to animal agriculture (though, as usual, there is no body of literature that clearly tracks specific policies or activities to particular valuations), such as:

- X welfare gains to anglers from a 1% reduction in fecal coliforms, phosphorous, and copper (as well as other contaminants), using TCM (Tay and McCarthy 1994),
- X WTP for returning water to an ecosystem, using CV (Loomis 1987).

Other studies look at environmental injuries that can be linked to agriculture, but where it is not possible to sort out the role of animal agriculture from other agriculture, let alone specific animal agriculture practices. These include:

- X benefits of reducing eutrophication from agricultural runoff, using TCM (Piper and others 1987),
- X value of siltation directly linked to agriculture, using TCM (Osborn and Shulstad 1983),
- X recreational value of wetlands (Bergstrom and others 1990),
- X various other studies of angling and other recreational activities (Duffield JW and Patterson DA 92; Rollins 1997; Smith and others 1983; Clark 1985; Navrud 1992; Kaoru and others 1995).

Other studies look at environmental injuries or water quality questions that are probably affected by animal agriculture, but the link is not so direct or clear. Some of these studies measure the value of changing a waterway to "fishable" or to "swimmable," or changes such as "fair" to "good" quality, without specifying the particular quantities of pollutants or their sources (Sutherland 1982; Smith and others 1983; Lant and Roberts 1990; Desvousges and others 1987). Such questions are useful because they are in terms that people can understand and put a value on, but they require several more steps before a particular effluent can be valued.

In order to determine the effect of changing recreational appeal on recreational businesses (a subject more closely related to the analysis in the second half of this report), it is necessary to determine what behavioral changes people will make in response to a particular impact. If the quality of a waterway decreases, the impact on businesses might be zero (people still buy the same things and simply go to a different stream to fish) or it might be substantial if they spend their money on something else (though the actual welfare loss, lost producer surplus, will be offset by the additional surplus generated by spending the money somewhere else).

Two Minnesota-specific studies can be found in Steinnes (1992) (impact of water quality on lakeshore land values, using hedonic pricing) and Welle (1986) (value of protecting vulnerable lakes from acid rain, using CV).

Much of the value of clean surface water, even when not specifically linked to drinking water, can also be attributed to health concerns (Lant and Roberts 1990), and so is closely related to the ground water analyses.

Soil Quality

The losses from soil degradation and pollution are theoretically largely internalized, since they are usually caused by the choices of the soil's owner, though some erosion problems are caused by someone other than the owner of the affected land. Gardner and Barrows (1985) used the hedonic price method to examine the effect of past erosion control on land prices and found that it only matters where the need for more control is obvious. This might suggest that more of the impact is externalized if only obvious depletion results in price changes, though other studies (Miranowski and Hammes 1984; Palmquist and Danielson 1989) did not report this pattern. Quantifying the externalities would require the initial step of determining if any of the costs are actually externalized.

There is a literature on "sustainable" livestock management which argues that low-level grazing and integrated animal-plant farms can have positive impacts on soils as well as other environmental goods discussed elsewhere in this report (Mearns 1997). It is not clear that there has been an attempt to quantify the value of these contributions, let alone identify what portion is external (even setting aside the debate over whether there really are positive impacts from actual practice).

Air Quality

Local air quality externalities from animal agriculture are captured in the LULU property value measures. Regional and global externalities, such as contributions to global climate change or ambient NO_x, have until recently been overlooked as externalities from animal agriculture. While literature now exists that clearly links the industry to regional and global air impacts, and other literature has attempted to value then value those impacts, a combination of these steps does not seem to yet exist.

Other Relevant Factors

Several sources of economic externalities are discussed in the Scoping Document but were not included as specific questions in this topic area. Given the similarities of these externalities to others discussed in this report, they are addressed here in parallel to the preceding topics, under the rubric of the "other relevant factors" subpoint.

Terrestrial Habitats

The GEIS Scoping Document does not specifically address the loss of terrestrial habitats associated with animal agriculture, though (in parallel with the discussion of aquatic habitats above), people are willing to pay something to preserve such habitats for use and non-use values.

Among the very few valuation studies that directly measure animal agriculture externalities is a CV study of preserving environmentally sensitive areas in England from modern farming practices (Garrod and Willis 1995). Beyond that, as with most of the topics discussed here, valuation requires that assessments of the physical impact be combined with people's values for habitats and biodiversity (such as those found in Moran and Pearce (1997)), and the value of recreational areas (discussed in dozens of studies in the literature).

Other Human Health Impacts

Beyond drinking water, there are various human health effects associated with animal agriculture. As with drinking water, the best way to value these effects is let the engineers and natural scientists estimate the exposure levels and the health scientists estimate how these map into morbidity and mortality outcomes. From there we can use economists' measured valuations for morbidity and mortality. Attempts to measure people's valuation for eliminating the exposure itself will tend to pick up things which are not actually health effects, namely irrational fears and misunderstandings about the actual effects. (There is substantial disagreement in the field as to whether to count people's irrational fears as real values. Even if they are counted, they should not be confused with the actual physical health effects.)

There is an extensive literature on willingness to pay for changes in risk of morbidity or mortality (Viscusi 1992; Viscusi 1993; Viscusi and others 1991). Preventative (mitigation) costs also offer a measure of health effects of environmental injury (Murdoch and Thayer 1990), as can medical costs of fixing the problem the environmental pollution creates (Dickie and Gerking 1991). For example, Harrington et al. (1989) examine the cost of preventive expenditure to measure the cost of giardia in the water.

By far the largest negative impact of animal agriculture on human health comes from eating its outputs. While these costs seem to be largely beyond the scope of the GEIS (being non-environmental by all definitions of the term except the biological, and not discussed in the Scoping Document), there has been some interest expressed in them. It is generally agreed in public health that consuming more animal foods contributes substantially to heart disease, diabetes, certain cancers, and other diseases. (A few summaries of this massive literature can be found in Messina and Messina (1996) and Messina and Burke (1997).) These negative health impacts dwarf the environmental health effects of the production process (and probably all involuntary environmental health hazards combined). As far as this author knows, no serious attempt has been made to calculate the direct human welfare cost of the excess disease attributable to animal product consumption. In any case, these are largely internal costs, since they are borne by consumers as a result of their own actions. To the extent that they result in socially-borne medical costs, there may be an externality (Gray and Malla 1998), though there may be no net cost because people may reduce medical costs by dying prematurely. (The one attempt to calculate the excess medical costs (Barnard and others 1995) is widely regarded as hopelessly flawed.)

By the same token, occupational hazards and exposures in animal agriculture probably account for a substantial portion of the non-dietary health impacts of the industry, again quite possibly more than the environmental health impacts. However, the voluntary nature of the employment

contract makes these costs internal as well, since enduring the risk is part of the employee-employer contract. (The social welfare ("justice") issue of many agricultural workers having little alternative employment opportunity is important as a larger social issue, but does not change this point.) There is an external cost, however, in the unhappiness the general public sometimes expresses about the unpleasant and unhealthy conditions faced by the workers that provide their food. This is a legitimate external cost that should be considered, though it has possibly never been quantified. It is expressed non-quantitatively in various statements that many people would be willing to pay more for their food if it meant that workers would get "fair" total net compensation. This takes the form of political statements in favor of protective regulation, willingness to buy coffee from producer cooperatives, and similar behaviors.

Problems of foodborne disease attributable to animal agriculture are more complicated. Some of the costs are similar to those of animal food nutrition -- largely internal to those buying the food, though possibly with externalized medical costs. But some of the costs are externalities exactly like other effluent, since the producers introduce human pathogens into the environment without paying the social cost, particularly the cost of infecting non-animal foods or any other food beyond their own products (Ackers 1998). It is clear that we can put a value on food safety (Hayes and others 1995). However, to determine the value of food safety externalities from animal agriculture, we need to be able to determine how many cases of foodborne illness (a figure placed above 200 millions per year in the U.S. by former State Epidemiologist Michael Osterholm) can be considered an external effect of animal agriculture. Calculating the *total* value of microbial contamination is much easier, though it still depends on the highly uncertain estimate of the prevalence of foodborne disease.

The creation of antibiotic-resistant pathogens as a result of using antibiotics in animal agriculture is a potential high-value externality. This is an extremely difficult impact to quantify though. It is only recently that a series of findings have confirmed the long-held suspicion that animal agriculture was contributing to resistant pathogens (see the Human Health report for more details and references). There has been discussion in the health literature trying to put numbers on the impact of antibiotic-resistance, but for obvious reasons this is an incredibly speculative process, even without trying to apportion the right share of the blame to animal agriculture.

Animal Well-Being

There is a respected tradition of suggesting that costs and benefits to animals should be considered (at some level, usually substantially lower than human utility on a per-individual basis) in utilitarian cost-benefit calculations. This is implicit in the common law and many of Western society's norms and regulations about treatment of animals. It has been more formally explored in a literature that traces back to J.S. Mill (Singer 1975; Singer 1980; Blackorby and Donaldson 1992). However, while there is much discussion of true animal well-being (as it would be measured by the animals as interested parties, as opposed to their physical health as commodities), for obvious reasons no serious attempt has been made to put a dollar value on the welfare losses animals suffer from their treatment. (Economic theory makes clear that the lack of a functional metric does not mean that such costs should not theoretically be added into cost-benefit analysis, though there are certainly many who argue that such an valuation for non-human animals would be inappropriate for other reasons.)

What has been seriously proposed and attempted is to quantify one of the external impacts of animal welfare losses, the feelings of humans about the treatment of animals in agriculture. Though it is difficult to physically measure animal well-being (which can be seen as based on philosophy, non-human psychology, or highly indirect physiological measures), it is relatively easy to measure the current state of people's feelings about it (which is a social construction like every other economic value (McInerney 1996)).

Most Americans agree that there is more that matters about an agricultural animal's well being than how fast she gains weight. Many people would be willing to pay something to reduce the impacts the industry is having on animals, and this is as legitimate a value as any other non-use value. (Many people are willing to pay to reduce the impact that they personally are having on the animals, such as by buying "free range" or organic animal products, but in terms of the welfare of the interested humans only, this is the mitigation of an internal cost. However, it provides data that could be useful in estimating the external costs, as well as further assessing society's values for animal well-being, whether it is an externality or not.) This value is a matter of preferences of members of our society. It is not a biological measure of the animals themselves, and does not involve a controversial claim about the welfare of the animals themselves. It is a straightforward measure of human welfare, and thus is a matter of economic externalities -- negative impacts on people not involved in the transaction that are not reflected in the market -- very closely analogous to ecosystem injury (McInerney 1991).

Studies of various populations in the U.S. and Western Europe have shown a consistent concern about the welfare of animals in agriculture (particularly "factory farms"). Results of the recent Lake Snell Perry poll released by the Humane Society of the United States (1999) found that 77% of Americans are "concerned about the inhumane treatment of animals on factory farms." Other studies found the portion of the population that says they are "concerned" (or some equivalent) about agriculture animal well-being is in the range of 80%, half of which are "very concerned" (or some equivalent) (Bennett and Larson 1996; Bennett 1997). People indicate a willingness to pay something to improve food animal welfare (Broom 1993). These observations and results suggest that externalities from animal well-being affect a large portion of the population and probably vary substantially across different production processes.

Various analysts point out that the marginal cost of some options for improving farm animal welfare from the status quo is low (McInerney 1996; Bennett 1995; Wilcox 1989), thus offering an easy net social welfare gain if consumer WTP to improve conditions turns out to be substantial. Hedonic and CV measures have been proposed for measuring this WTP (Bennett 1995; Henson and Beard 1993). CV is likely to be the only effective method because much of the externality is a non-use value. There have been a few attempts to actually measure it. Bennett and Larson (1996) used CV to measure U.S. students' willingness to pay for improvements in animal welfare in veal and egg production, and found significant positive results. They clearly state that the study is an exploratory test of the method rather than a finished study of value (their primary conclusion is that their approach could be used), and it uses CV study techniques that are no longer considered effective.

Bennett (1997, 1996) later carried out a more carefully-crafted CV study of consumers in the U.K., and found a significant WTP for eliminating battery laying operations. The study was affected by a low response rate and possibly various limitations of CV as applied, though the author shows that the result would still be nontrivial after adjusting for these. As with every other studied cited in this report, these results cannot simply be borrowed to provide definitive numbers for use by the GEIS, but they are among the few studies that directly put a value on a specific negative spillover from animal agriculture.

I.3 RECOMMENDATIONS FOR FURTHER RESEARCH ON SPILLOVER-TYPE EXTERNALITIES

The good news is that we know a lot more about valuing environmental and health externalities than we did only a few years ago and the knowledge base is growing rapidly. The bad news is that the questions are so big and the research so scattered that there is no body of literature that specifically addresses the general environmental impact of animal agriculture.

Any honest recommendation about further research for a policy application should start by trying to nail down the question the policy-makers really want to see answered. The recommendation should not be driven by what the analyst thinks is interesting (let alone by a simple cataloging of what we do not yet know), but by the policy goals. As such, this section asks some questions and lists some *possible* further research and what it could accomplish, without presuming to say "you should do X."

Any recommendation about doing further research in the area of spillover-type externalities hinges on a few overarching questions:

(1) Is cost-benefit type valuation desired?
(2) Are we interested in the spillover effects of facilities or animal agriculture in general?
(3) If we only want to value some of the externalities (notwithstanding the concern about doing that is discussed above), which ones?
(Ha and Morse 1998) Are we interested in externalities that affect people beyond Minnesota's boundaries? If so, how far do we extend our interests and how to we weight the interests of people outside Minnesota or the U.S. compared to people locally?

The reason for specifically asking the first question is that a cost-benefit approach has a substantial effect on the whole character of the analysis. It is the opinion of the authors of this section is that this approach is the only effective way to compare the many competing claims and interests with a common metric, allowing use to sort out the really big ones and get a rough cut at whether something produces a net cost or benefit. However, the additional step of putting valuations on the externalities, after identifying and quantifying their physical characteristics, will require additional work. Much of this work would draw upon benefits transfer and natural science/engineering knowledge that already exists, and so would be less expensive than new physical science studies, but it would not be free. The results would provide some numbers that made more sense to most reader than parts-per-million and such.

The second question was alluded to above. Unlike some of the other areas of the GEIS, where the analysis of all aspects of animal food production can be discussed and the reader could just set aside the ones that are not of interest, it is often difficult to make these separable in an economic analysis. An valuation study for surface water pollution, for example, could look at only the marginal cost of direct impacts from leaching and spills of stored manure, or it could incorporate the all of the impacts of animal agriculture, including cropland. While any given study might allow you to separate these and pay attention to whichever is of interest and ignore the other, the study design might give the reader only one bottom line. Thus, a political/policy decision needs to be made as to which measure is of greater interest. In some places it will be

much easier to look at only facilities, while in others it will be easier to look at the sum of facilities and other impacts.

By the same token, there needs to be a decision about which values are of interest, since this probably does not perfectly parallel the economist's definition of which values are external.

The recommended further research can be divided between relatively easy analyses (making the link where studies of A-to-B and B'-to-C have already been done) and *de novo* studies that measure something that has not been previously measured, and will require more work.

In many cases valuations can be calculated using existing studies that basically cover each step from action or policy to outcome, but have never been tied together. These would be relatively inexpensive studies. While doing a series of such valuations would be larger in scope and cost than a literature review, it would probably be smaller and cheaper than any new natural science study. Some of the most promising applications of secondary research to derive valuation numbers are:

- X valuing the probability-weighted cost of manure lagoon spills in terms of ecosystem, recreation, and mitigation costs,
- X estimating similar for ongoing non-point runoff into surface water, plus health impacts,
- X examining the cost of groundwater contamination risks, as a function of what we know about a given practice's probability of creating contamination,
- X assessing surface water impacts, measured in terms of downstream costs to municipalities or the costs of making comparable reductions in effluent from point sources,
- X generally linking the natural science and engineering information about the various human health impacts to existing quantifications of those impacts,
- X valuing recreational use of land that might be degraded.

Beyond these transfer studies, there are a few areas that seem particularly ripe for *de novo* research. Such research would be considerably more expensive than the transfer studies, but would have the advantage of getting directly to the numbers that are of most interest in the current discussion. In particular, these include:

- X property value (Smith and Desvousges 1986) impacts -- clearly this is important to many people in Minnesota, but the existing literature is simply inadequate to provide us with useful numbers,
- X a CV study of Minnesotans to determine WTP for maintaining small/traditional/"family" farms (capturing community economics, LULU, some environmental, and animal well-being issues) -- without such a value it is difficult to assess the basic question of the net cost or benefit of changing farming methods,
- X a CV study of the value consumers place on the welfare of food animals,
- X a CV study to measure how much value Minnesotans place on the survival of "Main Street."

The latter of these refers to a topic that is not discussed elsewhere in this report, though is discussed in detail elsewhere in the GEIS. It is included here because the type of research that must be done to address this question is the type of research discussed in this report. Without such economic measurements, it will be impossible to tell how much people care about changes to rural communities, no matter what studies we do to show tat the changes are occurring. The first two items on the list may offer great insight into what appear to be some of the most controversial and uncertain externalities motivating the GEIS process. These types of studies are likely to tell us more that is relevant to policy than will any natural science, engineering, or non-consumer-based economic analysis.

II. REGIONAL DEVELOPMENT EXTERNAL IMPACTS

INTRODUCTION TO MEASURES OF REGIONAL ECONOMIC IMPACTS

A. TYPES OF INCOME

This section presents the terminology that is commonly used in economic impact studies looking at the effects of one industry on other industries and businesses, communities and the state as a whole. While many of these terms are commonly used and understood, sometimes there are several common ways of using the terms and this can create communication problems. The definitions used in this report are as follows:

Employee compensation includes wages or salary plus fringe benefits such as health and life insurance, retirement payments, and any other non-cash compensation.

Proprietary income consists of self-employed income. For example, the income of self-employed lawyers, doctors, or business owners would fit here.

Profits and other property income include payments from interest, rent, royalties, dividends, as well as profits.

Indirect business taxes consist of excise and sales taxes but not income taxes or corporate taxes.

Personal income is the sum of employee compensation and proprietary income or the total of all forms of employment income.

Value-added income is the sum of personal income plus profits and other property income and indirect business taxes.

Gross Regional Income is identical to the value-added income of the region.

Gross Regional Product (GRP) equals the gross regional income. However, GRP is defined as the total spent on regional consumption and investment goods, total government purchases, and the total value of net exports from the region.

Region is defined to be any size from a small town or city, a county, a state, or even the nation.

Generally, gross regional income or total value-added is used as the key measure of the size of a regional economy. When measuring the impacts on the entire region, gross regional income or value-added is often reported because it is the most comprehensive measure.

B. MULTIPLIER (SPIN-OFF) EFFECTS

The economic impacts of adding a new industry to a region will vary depending on the extent to which that firm buys raw materials and other inputs within the region. The larger the volume of purchases within the region, the larger the regional multiplier or spin-off impacts. Conversely, the smaller the **leakages** (purchases from outside the region) the greater the spin-off effects.

Regardless of the type of models used, there are several basic concepts used in estimating the multiplier effects. While most of these concepts are directly applicable to input-output models described in the next section, they also apply to nearly all of the methods of examining multiplier or spin-off effects. These are defined below:

Economic Shock: In measuring the economic and fiscal impacts of the changes in an industry, we need to define exactly what that change is. Generally, this is called the economic shock. It is an exogenous change (a change from outside the model that you are using to explain the changes in other variables). With the feedlot issue, economic shocks might be drops in demand for livestock, changes in regulations at the state or local level that restrict the number of animals grown, or addition of a new meat packing plant that increases the demand for livestock locally. The economic shock is taken as a given or the starting point in any economic impact analysis.

Direct effects are the changes in expenditures in each industry or for each commodity that stem from the economic shock. These do not include any spin-off or multiplier effects. Estimates of these direct effects come from surveys or interviews with firms rather than from economic models.

Indirect effects are the changes in industries that sell to the industries in which the direct effects occur. For example, if a new hog operation opened in Murray County, the additional feed sold to that unit would be an indirect effect. The corn sold to the feedmill would also be counted. The fertilizer used on the corn and the trucking services used to deliver the fertilizer would be counted.

Induced effects are the changes in expenditures by consumers who work either in the industry directly affected or in industries that are indirectly affected.

Offsetting effects are changes in the local economy that occur as a result of your direct effect but which are not captured by backward linkages. For example, if you add a new hotel to a community, you need to check that this new hotel is not simply taking business away from the existing hotels. If this offsetting effect happens the direct effect could be zero. When a firm is lost from a community, other existing firms might simply expand and service the market. Again, there could be no net direct effect due to this offsetting effect.

Type 1 Multipliers report on the total change in income, counting both direct and in-direct incomes stemming from the economic shock compared to the direct change in income coming from the shock. A multiplier of 2.5 means that total income is 2.5 times as high as direct income and that the indirect effect is 1.5 times more than the direct. Type I multipliers are available for all types of income and employment.

Type 2 Multipliers report on the total change in income, counting direct, indirect, and induced income divided by the direct change in income. Type 2 multipliers are always higher than type 1 multipliers that leave out the induced impacts. Type 2 multipliers are controversial because they assume that any new income will be spent in exactly the same spending patterns as the average spending. This is rarely true and generally means that type 2 multipliers overestimate the true

impacts of an economic shock. On the other hand, type 1 multipliers completely ignore consumer spending and tend to underestimate the economic impacts. In practice, some economists use modified type 2 multipliers that give some consumer effects but not the full effect.

Backward Linkages refers to the purchases by an industry from its suppliers or the purchases by a household from the producers of the goods and services it uses. For a pork producer, the backward linkages are for feeds, equipment, trucking services, etc.

Forward Linkages refers to the sales to other industries or to final consumers. For a pork producer, sales to a meat packing plant are part of her forward linkages.

Final demand includes sales to consumers within the region being studied and to consumers and industries outside the region. Sales to governments within the region are also included in final demand.

Intermediate demand includes sales to all industries that use the product as part of their production process.

B. MODELS FOR MEASURING MULTIPLIERS

This section looks at the models used to estimate the regional spin-off effects. We provide a general description of these models and a critique, outlining their strengths and weaknesses. Models are simply maps of the economy. As a map outlines the major features of the land, a model outlines the major features of how an economy works. Just as no one type of map (U.S. interstate highway map, state road map, topological map) will serve all purposes, none of these models are useful in every context.

Economic Base Models are the simplest type of multiplier models. The multiplier is simply defined as:

Multiplier = Total employment/ Basic Export Employment

Exports are sales outside the region being studied, not necessarily international exports. Nearly all industry sectors have some export sales, especially when considering domestic exports (sales to people or firms in other states within the country).

When we consider the fact that some industries will purchase more raw materials and inputs within a region than others, it is apparent that the multipliers will differ between industries. However, the economic base model only has a single multiplier. Input-output models provide multipliers for each industry. For details on economic base models, see Shaffer.(1989).

Input-Output models are a double entry accounting system for all industries within a region. In the rows it traces the sales of each industry to each other industry, to consumers in households,

and to exports (See the rows in Table 1). For example, the Agriculture sector has total sales of 100 million in this hypothetical economy and sells 5 million to itself, 10 million to manufacturing, 10 million to retail, 15 million to households, and exports 60 million. In the columns it also traces the expenditures by each industry as it purchases raw materials and inputs from other industries, pays workers, and imports goods (See the columns in Table 1). For example, agriculture has total expenditures of $100 million. It buys 5, 20, 30 million from agriculture, manufacturing, and retail respectively. It pays households 25 million, partly as wages and partly at self-employment income and partly as profits. In addition it has to buy 20 million in imports from outside the region. The multipliers are derived from this table as shown in Appendix A. The only difference from the example in Table 1 and actual input-output models is the scope. Most have 528 industrial sectors rather than only three as shown in Table 1.

Table 1: Transaction Table for an Area Economy*

Economic Sectors	Agriculture	Manufacturing	Retail	Household	Export	Total Sales
Agriculture	5	10	10	15	60	100
Manufacturing	20	5	5	10	140	180
Retail	30	5	5	90	15	145
Household	25	80	30	10	25	170
Imports	20	80	95	45		
Total Expenditures	100	180	145	170		

* Example from Goode, 1982. See Appendix A for non-technical explanation of multipliers

Several authors are critical of input-output models. For example, Thompson and Haskins (1998) write that input-output models are "severely limited by both the assumptions made and the data used." (p.2) They are correct, but this can be seen as virtue rather than a weakness. It ensures that users can trace exactly what assumptions and data are used rather than having a mysterious black box.

When the input-output model is used to predict the economic impacts of a change in an industry, the following assumptions are made:

1) The output of each sector has a fixed production function, and there is no substitution between the input factors as change in the level of output occurs;
2) The change in the level of output being studied is not large enough to result in changes in the economies of scale;
3) The change in the level of output being studied is not large enough to result in changes in the prices of outputs or inputs;
4) The change in the level of output is not large enough to cause a change in the technology being used;
5) The percentage of imports for each industry will not be changed by the size of the impacts;

6) All increases in employment come from in-migration or new entrants to the labor force.
7) The estimates of transactions (as shown in Table 1) are accurate.

None of these is likely to be true for large changes in a business or economy. But if the change is small enough relative to the total economy that prices do not change, then the first four will be true. Assumption # 5 simply says that the market share of inputs between the region and the outside world will remain the same as the regional economy grows. Assumption #6 could be a problem in areas with large amounts of in- and out-commuting. This assumption is removed in the integrated econometric/input-output models. Assumption #7 seems obvious. However, since some of the input-output models have over 250,000 cells of information and over 3,600 pieces of regional data this can be a problem.

Regional input-output models typically are non-survey models that are built from the national model using regional data for each sector on output, employment, and value-added components. These non-survey models are 90 percent as accurate as the survey models but only about 10 percent as expensive. Consequently, practically no one uses survey models at the regional level. Non-survey models have two additional assumptions. These are:

8) the technology used in the region is identical to that used nationally; and
9) the percentage of regional purchases from local supplies is estimated accurately.

When the regional technology appears to be very different from the national average, many non-survey input-output models allow users to substitute survey data for the primary industries being studied. Likewise, semi-survey methods are sometimes used to improve the accuracy of the regional purchase coefficients for the principal industries. For additional detail on input-output models see Shaffer, 1989, p. 274-284; Miller and Blair, 1985; Goode, 1982; Olson and Lindall, 1996; or Otto and Johnson, 1993.

Integrated Econometric/Input-Output models blend the virtues of these two models. The most common integrated model (Johnson and Scott 1997) estimates the changes in out-commuting and in-commuting for a county, adjusting the number of in-migrants and new entrants.

This adjustment is important when estimating the fiscal impacts changes. If a person who lives in community A but commutes to work in community B takes a new job in his home community (A), he adds very little to the local demand for services and little to the local tax base. Likewise, additional in-commuters add much less demand on schools and other local public services than do new in-migrants.

The other advantage of these models is that the econometric portion includes equations to estimate the additional local government revenues and additional local government expenditures. These models, however, are in their infancy and need additional testing (Johnson 1996; Johnson and Scott 1997; Shields and Deller 1997; Shields 1998; Ha and Morse 1998)

Computable General Equilibrium Models (CGE) are simulation models which do not require all the assumptions in input-output models. Most CGE models allow impacts large enough that they result in changes in the prices of inputs or the outputs. Since economists spend most of their life studying the impacts of price changes, this drives them wild and these models have been wildly popular. Unfortunately, the data required for these models is massive. In fact, so much data is needed that the equations are not estimated using local data but rather coefficients are borrowed from other earlier studies. An advantage of these models is that they make explicit the many assumptions that often go into any analysis. The complexity of the models often makes them very time consuming and costly to develop. For an excellent overview of CGE models, see Robinson, 1989.

The CGE modeling that has been done on agriculture deals with national and international issues (Hertel 1990; Kilkenny 1991; Kilkenny and Otto 1994). No CGE studies were found that dealt with state or sub-state regions and livestock.

Comparable Areas Impact Studies are an approach for estimating the impacts of a change in one industry on the rest of the economy that does not use an explicit model. In this approach, the study area is compared to "similar" areas. Changes in key variables are measured before and after the impact in both areas. The differences in the two areas are assumed to be due to the impact. This inference is only valid if the two areas are identical and all the influences on their economies are identical. If they are of different sizes or different economic structures (percentage of firms in each industry), then we would expect different rates of growth and change in the two areas without any shock.

Before and After Impact Studies are identical to the comparable areas impact studies except that the same area is used. The changes in key economic variables are measured before and after an economic shock. Like the comparable area studies, this is only valid if the only difference is the economic shock. However, this is seldom the case.

II.1. CRITIQUE OF SCOPING DOCUMENT STUDY QUESTIONS

The questions considered in this part of the report are the first two (really three) in Section F, External Benefits and Costs. These are:

1. What are the overall economic benefits of animal agriculture (from all sources, including spin-off economic activity)? How do the benefits vary by type of production method, size, and location of operation and the animal population and density in the area? Factors to be considered include:

    a. wages
    b. value added to crop prices
    c. purchases of supplies
    d. property taxes
    e. tax base: and
    f. other relevant factors

2. How are the economic benefits (from #1) distributed locally (between owners, operators, employees, neighbors, and others) and in the state economy?

The questions in the scoping document present two major difficulties in terms of evaluating research related to regional economic impacts.

First, regional impacts will vary considerably given the nature of the policy or project being considered. If the primary policy concern is with the growth in large livestock feedlots, it would have been useful to explicit about that. If there is more concern with pork production than with milk or poultry, it would be useful to focus on that industry. If there is interest in establishing a set of policies or incentives that result in most farms being small rather than large, this needs to be explicitly considered in order to evaluate the impacts of these two types of industry structures. While the following review addresses these issues, the more focused the initial mandate the deeper the search and the analysis can be around a given issue or set of issues.

Second, the impacts will vary considerably depending upon the region being considered. This is due to both the structure of the local economy (and thus the backward linkages and spin-off effects), the size of the area considered, and the nature of offsetting effects. Local economies with a number of input suppliers will be hurt more by downturns in livestock production than ones without this. The larger the geographic area considered the larger the multiplier effects of a given livestock operation. Purchases outside the immediate local area (say a radius of 20 miles) are considered leakages and do not contribute to the multiplier effects within that 20 mile area. But if you consider a 40 mile radius, some of the previous "leakages" will now be within the region and contribute to spin-off effects. At the state level, the leakages will be much smaller than at the township or county level. If policies that discourage growth in livestock are implemented, the local, regional and state impact depends on how the labor and land previously used in agriculture are used. Generally, this land and labor will not be completely idle. In a few cases it might even by used in more productive ways, contributing more to the state's economy

than it did in agriculture. Without specifying the local economy, the region, and the policy scenario, neither prior research nor future research can provide much guidance on the probable impacts.

While the research considered can provide some insights to the questions asked, it will be necessary to be more specific on the location and the nature of the development to be considered in order to develop new research which can help policy makers consider the consequences of the options.

II.2. REGIONAL ECONOMIC/FISCAL BENEFITS AND COSTS

This section critically analyzes the research available on the regional economic and fiscal impacts of livestock production and processing. It considers the external effects captured in the market but does not consider environmental impacts that are outside the market. It does examine the research on overall fiscal impacts on local economies. It does not consider studies of changes in demand for community services (police, fire, etc.) due to demographic changes.

II.2.1 WHAT ARE THE OVERALL ECONOMIC BENEFITS OF ANIMAL AGRICULTURE (FROM ALL SOURCES, INCLUDING SPIN-OFF ECONOMIC ACTIVITY)?

This section reviews the conclusions of studies of the regional economic impacts of the livestock industry. Primary attention is given to studies that have been done on Minnesota's livestock industry, followed by those of neighboring states. Studies done in other parts of the nation that appeared to have useful insights for Minnesota are also covered. The studies are organized by species, followed by general livestock studies. Several very useful studies of agriculture's contribution to a state's economy were found but these did not focus on livestock and thus were not reviewed in detail (Tanjuakio and others 1996; Carter and Goldman 1998; Senf and others 1992).

Minnesota Dairy Production Studies: Two studies have examined the dairy industry's regional economic impacts within Minnesota.

In 1992, Ag*nomics Research estimated the impacts that differing production trends in the dairy industry would have on support industries and on state tax revenues by the year 2000. This study used regional input-output analysis to estimate the changes in payroll, employment, value-added income, and state tax revenue of alternative trends in dairy farm production. The impacts are overstated because the authors failed to account for the offsetting effects of increases in employment in other sectors due to the labor released from the dairy industry. The estimates provided in this study assume that none of the workers who lose their jobs as a result of reduced dairy farm production will ever find new jobs. Especially in tight labor markets, this is very unlikely. While some of those that stop farming will not work again, many of these are simply retiring. The reduction in employment comes from the fact that the younger generation is not going into the dairy farm. However, if that younger generation goes into a more lucrative type of work and earns more than they would have on the farm, the state's economy could actually

improve. It is difficult to determine what the net effect would be if this type of offsetting effect had been included.
In 1999 the University of Minnesota Extension Service published a report on the ***Economic Importance of Minnesota's Dairy Industry*** (Doherty and Morse 1999). This is a descriptive report that traces the linkages between dairy farms, dairy processors, and other sectors in the state's economy. It found that the 22,037 persons employed on dairy farms and processing plants support another 22,222 persons in support industries and another 9,437 in consumer sectors. In total, the dairy industry supports 53,696 jobs in the Minnesota economy. The value-added income earned by dairy producers and processors was $1.02 billion and supported another $1.39 billion in support and consumer industries.

While this study demonstrates the importance of the dairy industry, it can not be used to estimate the impact of expansion or contraction of the size of the dairy industry. Estimates of the impacts of expansions or contractions in the dairy industry would need to examine potential offsetting effects in other industries. To examine the net effects would require explicit definition of the offsetting effects in other sectors.

While this study by Morse and Doherty (1999) did not make the same mistake regarding offsetting effects, it is on the edge. Readers might assume that they could extrapolate the descriptive results shown in these types of descriptive linkage studies when there is a change in the size of the livestock industry. This is only correct if the proper off-setting effects are considered.

Both of these studies used IMPLAN regional input-output models. A discussion of IMPLAN strengths and weaknesses comes at the end of section 2.1.

Other Dairy Production Studies: Two other regional economic impact studies were found on the dairy industry, these were for North Dakota and Idaho.

A 1993 study examined the impacts on North Dakota of adding twenty 500-cow dairy herds to the state's economy. Using regional input-output analysis, this study estimated total value-added income to increase $18 million. The study reported that "Statewide, an estimated 580 full-time secondary jobs would be created, as well as 140 direct jobs" (Leistritz 1993). These estimates appear valid if the following two assumptions are valid. First, the new jobs go to in-migrants or to new entrants to the labor force. If the new jobs go to existing workers who are commuting to jobs outside the region then the new income to the region would be lower than estimated here. Second, if the jobs go to workers who already work within the region and in-migrants do not come in to take their jobs, this development could drive up wages in the region. Then the number of total jobs would not increase as rapidly as shown by this model. While it is unlikely that wages in the dairy farms would be high enough to cause these shifts, additional analysis would be needed to evaluate the degree to which these two factors are likely to influence the results.

Another 1993 study examined the impacts of dairy production in Idaho (Robison and others 1993). Idaho had 24 percent more cows in 1991 than in 1970, compared to a 25 percent drop

nationally (p.1). Using an Idaho regional input-output model, the authors estimate that milk production and processing account for 6 percent of the state's gross income in 1989, measured in value-added terms. Due to differences in the local economic structure the multiplier effects varied considerably from region to region. Like the Doherty and Morse (1999) study for Minnesota, this is a descriptive study that has no implications about the potential impacts of changes in the size of dairy herds.

Summary of Dairy Regional Economic Impact Studies: Only two of the studies report on wages or personal income. However, all five of the studies reported on the total value-added income impacts which includes wages as well as profits, interest, and indirect business taxes. Three of the studies reported the changes in value-added to crops or the number of additional jobs in crops as a result of the dairy production. None of these studies examined the changes in property values. Two estimated the changes in tax revenues, and four of five estimated the changes in total number of jobs in the state economy.

Three of the studies are descriptions of the linkages of the dairy industry to the rest of the economy and make no predictions of the impacts on the economy from changes in the dairy industry (Doherty and Morse 1999; Doherty 1999; Robison and others 1993). Two studies attempt to predict changes in the state's economy from changes in the dairy industry. The Ag*nomics study estimates overall trends in milk production and uses these estimates to predict the changes in the input and consumer sectors stemming from these changes. Since this study did not address the potential for offsetting effects, it is not possible to determine whether the net results will be positive or negative.

The Leistritz (1993) report examines the impacts of twenty 500 cow herds on the state's economy. If there are no price effects due to increased wages stemming from lack of sufficient in-migration of labor or due to shortages in other inputs, then these estimates are reasonable. Additional research would be needed, however, to confirm the validity of these conditions.

All of the studies address the general importance of dairy. Yet, none of them satisfactorily address the net changes in a region's economy due to changes in the dairy industry. The North Dakota study probably comes the closest to doing this but both the estimates and the offsetting effects would need to be localized to guide zoning policies. Since the nature of the impacts depends on the structure of the local economy, both the size and the distribution of the impacts will vary with the region being studied. This was demonstrated in the Idaho study that reported differing multipliers for the same processing sectors in different regions. Research on local feedlots would need to factor in offsetting effects. This will also vary widely from region to region. In areas of very high unemployment and little rural residential development there will be minor off-setting effects. However, if labor markets are tight and the land is likely to be used for high valued residential developments, the offsetting effects will be high

Minnesota Pork Production Studies: Only one study has examined the regional economic impacts of pork production in Minnesota.

A 1992 study by Jahae and van Staalduinen estimated the impacts of a proposed 1200 sow unit on Redwood County, Minnesota and on the economy of Minnesota as a whole. They concluded that final demand, total industrial output, property income, employee compensation income, total income, total value added, employment, and population would all increase in both the county and the state due to the proposed sow unit. They estimated a total effect, including indirect and induced effects, of 17 jobs in Redwood County (p. 19) and 25 jobs in Minnesota (p. 24). The production function was adjusted to reflect the fact that this new unit would be more efficient than the average unit in southern Minnesota (p.1).

Other State Pork Production Studies: Nine studies have been completed on the regional economic impacts of the pork industry.

An integrated input-output/econometric model was used by Iowa State University economists to estimate the impacts of different sizes of pork operations. These are reported in two articles (Otto and others 1998; Otto and others 1996). Thompson and Haskins (1998) provided a critique of these articles. All three are reviewed here.

The two articles by Otto, et al were based on the same research, originally reported in the 1996 Pork Industries Economic Review, published by the National Pork Producers Council. Starting with data from Purdue University on the costs of production and time required on farrow-to-finish operations of 150, 300, 1,200, and 3,400 sows, they used regional input-output analysis to estimate the multiplier effects of each size of operation. In the first paper (Otto and others 1996), they report the impacts under two different assumptions about corn. In the first case, they assume that the additional pork production will stimulate additional corn production, resulting in higher regional employment and incomes. In the second case, they assume that there already is a surplus of grain and that this is exported out of the region. In this case, the additional pork production would result in less exports but no increase in corn production. Consequently, the spin-off effects would be less. The data from Purdue shows a negative return to capital for the 150 sow unit with proportionally higher returns to the larger units.

The authors compared the impacts of a farm in each of the four sizes of sow units. Naturally, the larger units show more positive impacts on the total number of jobs. The scenario that assumed corn production would increase as a result of the pork production yielded slightly higher total employment but lower earnings per worker.

As discussed in a later section, the local impacts depend on the level of local spending for inputs and consumer spending by farmers. The Otto, et al. studies did not make any adjustment for potential differences due to size. As discussed later, this omission probably gave a slight advantage to the smaller farms since larger livestock farms spend more per acre (Chism 1993). Note that this conclusion is very tentative since the data on this relationship is based on a very small sample.

Thompson and Haskins (1998) correctly criticize the 1998 article (Otto and others 1998) for failing to compare the net impacts on the community if all the production had been in the smaller farms rather than the larger ones. That is, they argue that Otto, et al. should have held the level

of output constant for the four different sizes rather than comparing one very small farm with other larger farms. Using the data from Otto et al. reports, Thompson and Haskins show that twenty three of the smallest farms would produce the same amount as the largest farm. Using Otto et al.'s data, Thompson and Haskins go on to show that if all the production was in the smallest farms that these 23 farms would employee considerably more persons than the one large one (p. 4).

However, Thompson and Haskins incorrectly suggest that it does not matter whether or not a particular size of operation survives or not. Their argument appears logical if all sizes of hog operation are equally likely to survive over the long-haul. If one size is more likely to fail than the other, then we need to estimate the probability of survival and multiply that times the estimated impacts in order to get a reasonable estimate of the long-term impacts on the region. Neither Thompson/Haskins nor Otto et al. make this type of estimate.

Thompson and Haskins correctly state the strengths and weakness of formal mathematical models such as regional input-output models. They state:

> "They use a mathematical model to compute the conclusions that must follow from the assumptions they make. That way, if the methods are sound and they have done the arithmetic correctly, a reader is forced either to accept their conclusions, or to argue with the assumptions. The model rules out accepting the assumption but disagreeing with the conclusions that follow. That's the benefit and the power of formal methods of mathematical modeling. But it's also their weakness." (p. 7)

Note, however, that the conclusions that Thompson and Haskins refer to are the factual consequences of a specific economic shock. Input-output models can provide no "conclusions" on the correct policy to follow. Policy conclusions can come only with a blend of the factual impacts provided by the models and value judgements (Barrows 1993).

Thompson and Haskins then question the veracity of the cost data used by Otto, et al. While possibly this data is incorrect, Thompson and Haskins provide no evidence to this effect. An evaluation of the accuracy of this data is beyond the scope of this literature review and would take a team of production economists rather than regional economists.

In a 1994 study, DiPietre and Watson used input-output analysis to estimate the impacts of Premium Standard Farms on the state of Missouri and a five county region where the hogs and the employees are located. They estimated the impacts during the five-year construction phase as well as annually after the farm was in full operation (Table 2). These were ex ante estimates so it is uncertain if the direct impacts were as high as estimated. Naturally, the total impacts would be less than these estimates if the direct ones are lower.

The construction costs were industry estimates on a per sow basis not exact figures from Premium Standard Farms (p. 26). Type III multipliers, a special version of Type II which yield 15 to 20 percent lower results than the Type II, were used to estimate the total effects.

Table 2: Economic Impacts of the Premium Standard Farms, Missouri

Phase	New Jobs		Personal Income *	
	Five Counties	Missouri	Five Counties	Missouri
Construction #	873	1291	$87.2	$ 119.0
Operation +	957	1639	$82.0	$ 199.0

Results over the five
+ Annual impacts
* in Millions of dollars

Three additional studies estimated the economic impacts of pork production in their respective state using input-output analysis (McKissick and others 1998; Thornsbury and others 1993; Warner and Plaxico). The three states that were covered in these analyses were Georgia, Virginia, and Oklahoma, respectively. The Georgia study used IMPLAN for their analysis. The Georgia study estimated the total economic output, wages, and employment impacts of four different size plants on Bacon County, Georgia. The Virginia study estimated the economic and fiscal impacts of an expanding swine complex in Southside Virginia. This study used IMPLAN to derive multipliers. The authors then used these multipliers in the Virginia Impact Projection (VIP) model to estimate the impacts. The main impacts estimated were employment, income, retail sales, and tax base impacts. The authors of this study did not detail the VIP model or the procedure that they used, so no conclusions can be made about the validity of their results. The Virginia study also estimated the impacts that would occur during the construction phase of the new plant. The authors of the Oklahoma study did not specify what kind of model they used in their analysis. They just stated that it was an input-output model. Thus, no conclusions can be made about their results.

A 1998 study was conducted in Canada that combined economic impact analysis to estimate income and employment impacts and social impact analysis to assess government and community concerns (Serecon Management Consulting Inc.). This study used a form of economic base model. Consequently, the results can provide no detail on the sectors that are impacted.

The studies that come the closest to providing the type of information needed for evaluating the feedlot issue at the local level or to evaluate proposals concerning the most desirable structure of pork farming (mostly large or mostly small) are the ones by DiPietre and Watson, 1994; Otto, Orazem, and Huffman, 1998; and Otto, Lawrence, and Swenson, 1996. However, even if their results are reasonable they would not translate easily to Minnesota's economy and fiscal structure. Since most decisions on zoning are made at the local level, estimates need to be run for each proposed project rather than at the state level.

Minnesota Poultry Production Studies: Only one study was found that dealt with the economic impacts of the poultry industry in Minnesota.

A 1998 study examined the importance of the poultry industry on Minnesota's economy (Morse 1998). This study only traced the linkages between the poultry production sector, the poultry processing sector, and the other sectors in Minnesota's economy. The study did not try to estimate the economic impacts of expansions or contractions in the poultry industry.

By using regional input-output analysis, Morse found that the total number of jobs that were created in Minnesota due to the poultry industry was 26,344. Only 10,308 of these jobs depended directly on the poultry industry. Over 10,000 jobs were created in the supply industries, and over 5,000 jobs were created due to increased spending by employees in the poultry industry.

Besides employment impacts, this study estimated the income impacts associated with the poultry industry. It was found that poultry producers and processors earned income of $317 million. When the supporting industries are included, the estimated earned income for the poultry industry was $905 million.

Other Poultry Production Studies: Two other studies examined the economic impacts of the poultry industry. The first study is for North Carolina, and the second study is for Alabama.

A 1995 study estimated that the poultry industry, including both production and processing sectors, in North Carolina helped to create approximately $1.6 billion in state income (Vukina and others 1995). The poultry industry also supported close to 52,000 jobs. However, this study is also a descriptive one and can not be used to estimate the impacts of changes in the size of the poultry industry.

Another 1995 study examined the impacts of the poultry industry (Hurst and others 1995). The authors studied the impacts of the broiler and egg industry on Alabama. They used the RIMS II input-output model to estimate these impacts. The authors of this study did not explain their procedure for estimating the economic impacts of the poultry industry. Thus, we do not report the results since it is impossible to evaluate the validity of their assumptions and methods.

All of the poultry studies are descriptive only. They can not be used to estimate the impacts of an expansion or contraction of the poultry sectors.

Minnesota Beef Production Studies: No articles were found dealing with the economic impacts of the beef industry on Minnesota.

Other Beef Production Studies: There were only two articles found about the economic impacts of the beef industry. Both studies were for North Dakota.

A 1992 study by Bangsund and Leistritz estimated the economic contribution of public land grazing to the North Dakota economy. This study was only a descriptive study. It did not try to estimate the impacts that a contraction or expansion in public land grazing would have on North Dakota.

The authors estimate that public land grazing contributed about $153.4 million to the North Dakota economy in 1991. Public land grazing also generated over 1,800 jobs. The authors only gave secondary employment impact estimates. Thus, public land grazing probably generated more jobs than just the 1,800 stated in the study.

A 1993 study by Leistritz and Sell estimates the economic impacts of expanded backgrounding on the North Dakota economy. Backgrounding is a program in which producers of feeder cattle retain the cattle until they achieve a gain of 150 to 300 pounds after weaning instead of selling the calves out of state. The authors estimate that expanded backgrounding would generate 1,030 full-time secondary jobs. State tax revenue from additional use and sales tax, personal income tax, and corporate income tax receipts were estimated to total approximately $1.4 million.

The employment impact estimate was only for secondary effects. Thus, the total employment impact is probably higher. Also, part-time employment was not considered in this study. When adding full-time and part-time employment, the number of jobs generated will increase. However, the estimates in this study assume that these jobs are going to in-migrants or currently unemployed residents. If current residents who are employed by other industries quit their jobs to seek work in this industry, the employment impact will be dampened.

Strengths and Weakness of IMPLAN Regional Input-Output Model and Data: Since most of the regional input-output models used were built around the IMPLAN model and database, we consider the strengths and weakness of this model and database.

There are three major data weaknesses in the IMPLAN input-output models. They are: 1) the value of inputs purchased by a livestock producer reflect national averages for usage/head and national prices; 2) the amount of labor used in livestock is estimated to be one worker per farm, regardless of size of the farm; and 3) the regional purchase coefficients are estimated from secondary data and might be inaccurate.

Ikerd suggests that the default IMPLAN data might understate the impacts of owner-operated family farms on retail employment and overestimate their impacts in manufacturing (p. 165).

From the data perspective, the major strength of the IMPLAN software is that it allows the analyst to modify all three of these with local data when it is available. For example, Otto, Lawrence and Swenson (1996) use cost data from Indiana to run the analysis of different sizes of pork operations in Iowa. Morse used data from the Minnesota poultry industry to adjust the input purchases when studying turkeys, eggs, and broilers. Doherty used cost data on different sizes of dairy herds to avoid the first two problems. The third problem was addressed by several authors but none adjusted the regional purchase coefficients.

Two general weaknesses of all input-output models are: 1) they are inappropriate to use for very large impacts; and 2) they do not account for commuting. If the impact is large enough that it leads to increases in wages or in the prices of any inputs, the results stated by IMPLAN will be overstated (Kraybill, 1993). After commuting is accounted for the employment impacts are likely to be considerably smaller than derived from IMPLAN.

In evaluating IMPLAN studies, one should ask if the researcher did the following:

1) Compared the national expenditure patterns to regional ones and adjust where necessary?

2) Validated the models estimated regional purchase coefficients and adjust as necessary?

3) Examined the labor and employee compensation coefficients and adjusted as necessary?

4) Considered the offsetting effects when defining the economic shock scenario?

5) Considered whether the size of the economic shock would be so large that prices would increase for labor or other inputs?

The major strength in regional input-output models is that they can provide detailed estimates by sector. This allows the researcher or the public to check the validity of the assumptions used and the reasonableness of the results.

2.2 HOW DO THE BENEFITS VARY BY TYPE OF PRODUCTION METHOD, SIZE AND LOCATION OF OPERATION AND THE ANIMAL POPULATION AND DENSISTY IN THE AREA?

Is a community's economy better off with a lot of small farms or a few large ones? This is the question examined in this section. In many cases size is also related to the production methods with small farms being independently owned and operated and the larger ones be vertically integrated. This section looks at the research on whether large operations and vertically integrated ones yield more or less community benefits than small independent operations. While the density of animals is often greater in the large integrated operations, no separate studies were found of the separate impact of the population and density, controlling for size. This section looks at research which has been done on the differences in wages, value added to crop prices, purchased supplies, property values, tax base, jobs, and poverty.

2.2.1 **Wages**

This section reviews the literature that deals with the effects that animal agriculture can have on wages, salaries, and benefits.

Four studies were found that contributed information regarding the effects of pork production facilities on wages, salaries, and benefits. Two studies were for Iowa. The second two studies are for the nation as a whole.

In the 1998 study written by Otto, Orazem, and Huffman, they found that the earnings per worker were positively related to the size of the farrow-to-finish operation. Workers in the 3,400 sow

units earned an average of 16 percent more than those in the150 sow units. Thompson and Haskins (1998) do not challenge these estimates on the quality of jobs by size of operation.

Grey's (1998) chapter about the effect that the new IBP plant in Storm Lake illustrates the difficulties of comparing changes in wages in two points in time. Grey compares the wages at the previous Hygrade plant that went bankrupt with the new IBP plant rather than comparing the IBP wages with what was currently available in the community.

While it would have been better for IBP workers to have earned the same wage rates as the Hygrade workers, the high wages were one of the factors for the closure of the Hygrade plant. Were the IBP workers better off with their IBP jobs at the low wages than if they had been unemployed or had to move or to commute? Since the IBP workers were free to either commute or move, one could reason that they picked their best feasible alternative and thus are better off with the IBP jobs than without them. On the other hand, to conclude this we would need to know if the workers were given reliable information on the wages, benefits, cost of living, and working conditions. While a comparison to the Hygrade jobs is not realistic simply because those jobs no longer exist, we do know that the IBP jobs were relatively low paying.

Miller (1991) reported on a survey sponsored by the National Pork Producers Council of 1,472 producers and 1,270 employees. Approximately 91 percent of the employees worked in hog operations that produced 100 or more head of hogs per year, with 25.7 percent working in herds of 500 sows or more. Eighty nine percent of the employees were in units of less than 1,000 sows. Twenty eight percent of the employees had a four-year college degree or more, while another 33 percent had two-year college programs.

Hurley, Kliebenstein and Orazem (1996) used the 1995 National Pork Producers Council-National Hog Farmer Magazine (NPPC-NHF) data to examine the structure of wages and benefits on pork farms. They used a regression analysis to separate out the influence of formal education, years of work experience, length of work tenure, gender, output levels, number of employees, region, and labor market variables. The labor market variables includes: an index of employment concentration, percent without high school diploma, employment rate, average income, and percent employed in agriculture. Their major findings were:

> "1) wages do not differ across regions of the county but, instead, reflect differences in worker skills and firm size consistent with a nationally competitive labor market; 2) there is no evidence that large producers have market power in local labor markets that enable them to pay lower wages than competitors; 3) the wage premiums in larger firms seem to be partly explained by the greater use of skill-intensive technologies in large firms; 5) the remaining wage premium in large firms seems to be consistent with returns to scale that are partly shared with labor; 6) salary, benefits, and a safe working environment all contribute to worker job satisfaction so that firms offering better working conditions and benefits can pay lower salaries than competitors with fewer benefits or inferior working environments" (Abstract) .

2.2.2 Value-Added to Crop Prices

Will additional production in a county or region lead to higher crop prices? Or will imports from other counties and regions result in a fairly uniform price across large regions? No articles were found on this topic but one is underway as mentioned later.

2.2.3 Purchased Supplies

Two streams of research are relevant here. First, regional input-output analyses provide details on the types of supplies that are estimated to be purchased by animal producers. The second stream of research examines the question of whether large livestock farmers buy less locally than small ones.

Purchased Supplies from Other Economic Sectors: Table 3 shows the distribution of economic impacts by various sectors for a 1200 sow unit on the state of Minnesota in 1991 (Jahae and van Staalduinen 1992). Not all of these supplies were purchased directly by the hog operation. For example, the dairy farm products would have purchased some feed grains, soybeans, and hay to produce milk that was purchased by hog operations. However, all of the amounts shown in Table 3 are spin-offs of the 1200 sow unit.

Table 3: Indirect Effects of the 1200 Sow Unit on Minnesota, 1991

Industrial Sector of Purchased Supplies	**Value of Supplies**
Dairy farm products	28,200
Feed grains	103,700
Hay and pasture	31,700
Oil bearing crops	14,900
Agricultural forestry	17,200
Maintenance and replacement	10,700
Farm equipment	15,800
Railroads	12,200
Motor freight transportation	38,600
Electric services	33,500
Other wholesale	107,400
Other retail trade	11,900
Banking	46,600
Credit agencies	9,700
Insurance carries	21,200
Insurance agents	4,900
Real estate	100,100
Hotels and lodging	3,500
Misc. Repair shop	7,900
Accounting, audit	6,000
Eat/drinking place	6,000
Auto repair	13,500
Other medical	21,700
Other indirect	195,200
Total	**862,200**

Regional input-output analysis can trace the impacts to 528 sectors in the economy. Most of the reports aggregate to avoid overloading the readers. Table 3 is included only to illustrate the type of information provided on purchased supplies by regional input-output models. The impacts for any specific feedlot will vary with the location of the feedlot, the nature of that county's local economy, the nature of the feedlot, and the spending patterns of the producer. In addition, the net impacts will vary with the type of other development displaced, if any.

All non-survey input-output models must estimate the amount of inputs to a sector which are imported from outside the region being studied. Generally, this is considered one of the weakest aspects of the non-survey input-output models (Stevens and others 1989; Ralston and others 1985; Swanson 1998). Most of the regional input-output models use an econometric estimate of the RPC or estimate it via the supply-demand pool method (Olson and Lindall 1996). The later method assumes that all local purchases come from local supplies prior to going to imports.

The second stream of research attempts to examine the location of the purchases of inputs. In fact, the above estimates include data on the percentage of local purchases that come from local supplies (called the regional purchase coefficient).

Purchased Supplies by Location of Purchase: Do large livestock farmers buy less locally than small ones? If so, the multiplier or spin-off effects of large farmers are less than for smaller ones. Sociologist Walter Goldsmidt predicted the demise of rural communities based on the view that large farms would buy less locally (1978).

Marousek (1979) surveyed 84 Idaho farmers (49 small ones and 35 large ones) and found that small farms spent a higher percentage of their production expenditures locally than large ones (59 versus 55 percent). However, spent nearly five times more than small farms in the local area. He found that 22% of the small operators expected to cease farming within five years but none of the large ones did (p. 58).

The Marousek (1979) study is one of the few input-output studies that uses survey data to develop the regional input-output model. The model is highly aggregated (19 sectors compared to recent models of 528 sectors) and has only two agricultural sectors. These are: "large farms" and "small farms." To use input-output with this type of aggregate sectors in agriculture, it is necessary to assume that the type of crops and livestock in large and small farms is identical. Assuming this, he uses the model to examine the trade-offs between large and small farms on the rest of the community's economy. He found that:

> "Displacement of small farms by large farms results in greater regional income whereas increasing the number of small farms yields greater regional employment. Agricultural output is comparable for the two farm size structures" (p. 61).
>
> Chism and Levins (1994) found that farmers generally believe that large farmers are less likely to buy locally than small ones. They surveyed 30 farmers on their opinions about local vs. non-local spending. They found that these farmers felt: 1) larger farmers would benefit more from small differences in prices and would have greater incentives to

purchase in non-local markets, 2) large farmers had greater capacity to shop around the region for discounts, and 3) large farms often needed specialized inputs not available locally (p. 1). In addition, Chism and Levins examined the expenditure records of crop and livestock farmers to determine their actual spending patterns.

The Chism/Levins article is cited widely (Ikerd, 1998, p. 157; DeLind, 1998, 29; Thu and Durrenberger, 1998, p. 7; Lasley, 1995, p. 127). Yet, everyone that has cited it did so incorrectly with respect to economic impact analysis. They all conclude that Chism and Levins provides support for the view that small livestock farms buy more locally. In fact, they might, but the Chism and Levins article doesn't report this.

Chism and Levins present a graph that shows that the percent of local farm expenditures in livestock operations falls sharply as farm size increases. However, a totally different picture emerges when you consider the per-acre spending. For livestock they point out that:

"the relationship between sales volume and local spending per acre was relatively flat. It appears that livestock operators spend a certain base amount locally, whatever their size. As operations get larger, any additional spending occurs outside the local area" (p. 2).

In fact when Chism (1993) compared the average expenditures per acre of large and small livestock farmers, he found that:

> "On the acreage basis, both groups of livestock farmers surpassed the overall weighted average of local spending, $251.91 per acre. The small livestock farmers' weighted average of local spending on the acreage basis was $310.51 per acre, while the large livestock farmers had a weighted average of $367.58 per acre. While this may seem to contradict the notion that only smaller livestock farmers are more apt to spend locally for their farming needs, it is important to recall that the larger farmers had much greater spending volume to spread over relatively fewer acres of land." p. 33-34.

Chism (1993) points out that the more livestock intensive farmers spent more locally on a per acre basis than the more crop intensive farmers. From this, Chism suggests that:

> "By creating a hostile climate for livestock farmers, some small, rural communities may be putting greater negative economic pressure on many of their agricultural merchants by unwittingly lowering the total volume available from the surrounding countryside" (p. 44).

The spin-off or multiplier effects depend on the total amount of spending per acre not on the percent of spending by the livestock units. Since the larger livestock farms spend more per acre but spend about the same amount locally, they spend a lower percent of the total. But the percentage is meaningless in estimating the spin-off effects.

At worst, the Chism/Levins study implies that large livestock operations are not more beneficial than small ones. This is a very contrary view to that reported in the literature citing this study (Ikerd 1998; Thu and Durrenberger 1998; Lasley 1995). At best, the Chism/Levins study suggests that large livestock farms are beneficial to local communities. This would be the case if the larger units are more likely to survive than the smaller units. In this case, the expected value of the local spin-off effects are larger for larger farms than for smaller farms.

The Chism/Levins study has two methodological problems, however. The livestock conclusions are based on a very small sample (12 farms). "Local" was defined as a 20-mile radius of each farm. While this seems reasonable, it leaves unclear where the non-local spending goes. Does it go to other rural areas? Given today's transportation networks and the distance that many rural people commute to work, should alternative estimates be considered?

In a staff paper from Iowa State, Lawrence, Otto, Meyer, and Folkerts report on a 1993 survey of pork producers' spending patterns. These authors report that a larger percentage of large producers travel longer distances to purchase inputs compared to smaller producers. However, they do not report the per-acre spending which is needed to determine the local economic impact. Otto in summarizing this work writes:

> "Producers of all size operations appear to be willing to shop in more distant communities for their inputs and services. For producers who indicated they did not buy inputs in the nearest community, quality and service were most frequently given as reasons when professional services such as accounting, banking, and veterinary medicine were involved. Pricing became the predominant factor in producer decisions to purchase general supplies and hog equipment. Producers' concern with price and non-price attributes of inputs and services suggest that local agribusinesses in rural communities are likely to face increased competitive pressures from larger and more distant businesses. Rural agribusiness firms that are unable to provide specialized expertise may have difficulty competing in this environment" (p. 17 and 18).

2.2.4. Property Taxes

Property values might increase in value due to the additional economic demand stemming from growth in the livestock industry. Or, property values might fall due to the negative influence of odors or water pollution or other externalities. This aspect is reviewed in the other part of this report.

2.2.6 Tax Base/Taxes

This section reviews the documentation regarding the effects of animal agriculture on the tax base, and taxes in general, of the respective region. First, the findings from articles that deal with Minnesota agriculture will be summarized. Then, the findings from other states are reported.

Minnesota: Currently there are no completed studies on the tax base or taxes stemming from animal agriculture.

Other States: Only two studies were found that dealt with the effects that pork production could have on taxes and the tax base.

In a 1998 Iowa study, Otto, Orazem, and Huffman estimate the changes in expenditures and revenues for local units of government as a result of four different sizes of farrow-to-finish operations. Since the authors do not report any details on the nature of their model, it is difficult to evaluate the veracity of the estimates.

DiPietre and Watson (1994) also estimated the public sector fiscal impacts. They left plenty of room for improvement in the estimation methods for the public expenditures. They simply assumed that the cost of repair to county roadways damaged by construction vehicles was $3.7 million or equal to the amount paid by Premium Standard Farms for this same purpose. In addition, they included $115,000 for "on the job training." Despite the addition of 873 jobs over five years, they assumed no additional costs for police, fire, sanitation or other general public service costs. Equally as interesting is that they assumed no additional costs for any local public services during the operational phase, despite the addition of 957 new jobs. This might be reasonable, given the depressed conditions in the region. However, the report provides little justification for these assumptions on expenditures.

2.2.7 Poverty

Goldschmidt (1978) suggested that communities that have primarily small farmers are better off because the smaller independent farmers will be more interested in the well-being of their local communities and will invest in its institutions. In contrast, he reasoned that large commercial farms will have separate management from labor and absentee ownership, resulting in lack of interest in the well-being of the local community. He compared two California communities, confirming his hypothesis. Goldschmidt examined the communities of Arvin, CA (with primarily large farms) and Dinuba, CA (with primarily small farms). He examined detailed information on the character of their agriculture and a wide variety of other social and economic variables. On the retail businesses, he found that Dinuba had more than twice the number in Arvin, "showing that the small farm population supports small business to a far greater extent." (p.381). In addition, Goldschmidt points out that the "total volume of expenditure and the volume per person is appreciably smaller in Arvin than in Dinuba." (p.391). However, he also suggests that this could be due to the influence of another urban center near Arvin. As with other comparable area studies, it is difficult to know how much of the difference between two areas is

due to the farm size and how much is due to completely unrelated variables which also influence the number of businesses and extent of local shopping.

Durrenberger and Thu examined Goldschmidt's findings relative to the Iowa pork industry. They conclude that "it is more advantageous for Iowa to have more hog farmers rather than more hogs" (p. 409). Quoting a longer summary passage, they write:

> Since total hog production is a function of the number of small-to-moderate hog farms, large hog operations have a deleterious relationship to rural hog production. Large hog operations are related to a decline in small and moderately sized operations. The more farms that produce hogs, the fewer people that use food stamps. This analysis suggests it is important to maintain and create small-to-moderate sized hog operations, not large ones (P. 413)

However, the evidence and the analysis in their article does not support these conclusions. First, Durrenberger and Thu examine the correlation between farm size and number of farms. They find that as farm size increases, the number of farms decline, implying one causes the other. However, their data shows that the most urban counties have the largest number of farms and the smallest ones. They do not explore the possibility that this reflects the non-farm opportunities in more urban areas. Seventy five percent of small farm operators report their principal occupation outside of farming. On the average, the small farms earned $42,686 in nonfarm income while losing $4,593 on their farming operations (Steele, 1992). The smaller farms near urban areas are more feasible because of the greater number of nonfarm jobs. The larger farms in rural areas might not be forcing small farms out but simply required for families to earn sufficient income. A second factor might contribute to small farms near urban areas. Near urban areas many farmers expect to sell their land for subdivisions as part of their retirement plan. Consequently they can afford to hold onto the land in smaller farms in order to qualify for lower agricultural taxes.

Next they observe a negative correlation between the number of farms per capita and the percentage of people on food stamps. Note, however, that the relationship between the percent on food stamps and the number of farms would have been positive rather than negative if they had not first divided farms by population. They did not explore whether the more urban counties had higher rates of participation in food stamp programs or other factors that might have influenced the differences in rates between these regions. Rather, they attributed all of these changes to farm size. A complete model of the factors that influence food stamp participation is needed and a multivariate analysis to control for the multiple factors. Without this, it is difficult to know if the correlation they find has any meaning.

Why was food stamp participation selected as "the most direct measure of social and economic well-being." (p.411)? Why not income per capita or percent in poverty? While food stamp participation might indeed be the best measure, Durrenberger and Thu provide no conceptual or empirical justification for their assertion. Would the conclusions they reach hold if these other measures for local well-being were used? Since this is only a literature review, we do not attempt to answer this. Further research should explore this.

Using regression analysis, MacCannell (1998) studied the relationship between farm size and poverty rates and family incomes. This study is not germane to the livestock issues in Minnesota since it dealt with conditions in four Sunbelt states: California, Arizona, Texas, and Florida. Further, he excluded the counties that were principally grain and livestock counties. (MacCannell 1988)

Flora and Flora (1988) studied the relationship between farm size and community well-being in farming areas west of the Mississippi River. Minnesota is not included in the areas studied except for wheat production in the northwest part of the state. They examined 234 counties that had 20 percent or more of the personal income from wheat and/or livestock but excluded the industrial agriculture counties in California and Arizona (p. 80-81). The Floras found that poverty declined most rapidly in the livestock counties but was initially higher (p. 100

Lobao (1990) found that industrialization of agriculture had little impact on the quality of life. Summarizing the conclusions about regional differences in farm structure and well-being, Lobao and Shulman (1991), write:

> First, compared to nonfarm industry, farming is not a strong determinant of socioeconomic conditions even in agriculturally dependent areas (van Es and others 1988). Second, the effects of medium-sized farms tend to be constant over the regions examined; the studies verify or imply that such farms are related to better socioeconomic conditions. The impacts of small and large farms by region are less clear. Skees and Swanson's (1988) study suggests that small farms may lower well-being, a finding that was confirmed in a national study of U.S. counties (Reif 1987). The effects of large-scale farms do no manifest a consistent pattern across regions. (p. 568-569)

Lobao and Shulman (1991) studied the impact of farm size and farm industrialization while controlling for the non-farm economic structure and other variables within regions. They found that the impact of industrialization in agriculture varied by region with fewer adverse affects in the midwest than in the south. Using data on 2,349 nonmetropolitan counties for the 1970 to 1980 period, Lobao and Shulman ran multiple regression analyses on poverty rates. They summarize their work as follows:

> "Rural poverty is largely a function of the prevailing economic structure, the balance of social relations and spatial characteristics. Of these sets of factors, social relations variables tend to explain more of the variation in rural poverty rates, and farming patterns explain the least. Industrial structure followed social relations as an important correlate of poverty." (pp. 587-594)

The farming patterns included indexes for industrialized farming, larger family farming, and smaller family farming. The regional industrial structure variables included: percent in peripheral employment; percent in state employment; and non-farm establishment size. Social relations variables included: percent unionized, per capita AFDC payments, percent nonwhite,

median education, percent unemployed and earlier poverty. The spatial variables included: percent farm-to-rural population in the county, the percent urban, metropolitan adjacency.

2.2.8 Employment Comparisons: Contract vs. Independent Farmers

In his analysis of independent hog farming and contract hog production, Ikerd (1998) states that a sustainable agriculture paradigm is the only way for rural America to survive. The sustainable agriculture paradigm "relies more on people, including the quality and quantity of labor and management, and relies less on land and capital" (p. 158). Ikerd criticizes a study done in Missouri about the future of pork production in the state (DiPietre and Watson 1994).[4] Ikerd argues DiPietre's report indicates that the drop in total pork production in Missouri is the main problem in the state and that the solution is to bring in large corporate hog producers. However, Ikerd writes:

> "Only to the extent that it results in higher quality employment opportunities does increased hog production contribute to economic development of rural communities. Since large-scale confinement hog operations seek to reduce total costs by using production methods that allow fewer people to produce more hogs, the substitution of capital and mass-production technologies for labor and management is the primary advantage that large, specialized hog production units have over smaller, diversified operations. The displacement of family farms by large-scale hog production systems reduces rather than increases total employment in pork production." (p. 161)

Ikerd goes on to provide estimates of the number of farmers displaced by a $5 million investment in contract farrowing and finishing operations. There are two critical assumptions in his analysis. First, he assumes the multiplier effects for both the contract units and the independent units are the same. Yet, since contractors buy much of their feed while independent producers often grow theirs, the multipliers would be higher for contractors than for independents. Second, he assumes a fixed demand for hogs so that growth of one type of producer directly displaces another type of producer. This might or might not be true but Ikerd provides no evidence on this. In summary, the estimates provided by Ikerd are only valid if these assumptions are valid and no evidence is provided on them.

2.3 HOW ARE THE ECONOMIC BENEFITS DISTRIBUTED LOCALLY (BETWEEN OWNERS, OPERTORS, EMPLOYEES, NEIGHBORS, AND OTHERS) AND IN THE STATE ECONOMY?

Table 4 illustrates the type of employment impacts sometimes reported in regional input-output studies. Estimates can also be made for these same groups for all the spin-off industries as well.

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[4] The DiPietre 1992 study was not available for review. Comments reflect Ikerd's discussion of this paper.

However, generally the total change in value-added income is reported rather this specific breakdown.

Table 4. Estimates of Income Impacts by Type of Recipient for the Dairy and Poultry Industries, Producers and Processors, Minnesota

Type of Income	Dairy Industry *	Poultry Industry #
Employee wages and salaries	50.0	54.5
Self-employment income	9.3	14.5
Returns to capital	33.4	24.5
Indirect business taxes	7.3	5.5
Total Value-Added Income	100.0	100.0

* Doherty and Morse, 1999,

\# Morse, 1998.

3. INTERVIEWS WITH RESEARCHERS CONDUCTING ONGOING WORK

Doherty (1999 forthcoming) is working on estimates of the impacts of several sizes of dairy herds. Using input-output, she will compare the impact on the state if all herds were in different size categories. She points out in the preliminary work that the survival rate of the different sizes of firms will make a difference in the actual impact. For example, if the larger dairy farms have a larger impact (controlling for total output) but a lower survival rate, then their impact would be diminished. Unfortunately, her research does not have the survival rate factored into the final estimates. This could be done in future research, however. A master's thesis will be available later this summer or fall. It is an initial piece of work and not peer reviewed.

Research is underway by the North Central Regional Center for Rural Development on a number of economic and fiscal impacts of the Seaboard Corporation, a large integrated industrial pork production facility in Texas County, Oklahoma. The study uses the comparable area approach and is currently in the peer review process.

Two projects are underway which measure the changes in tax revenues and changes in expenditures in counties. Inhyuck Ha is developing an integrated econometric/input-output model for Minnesota counties and has preliminary results for dairy farms in four counties. Diego Platas is using the same model to examine different types and sizes of swine operations in a sample of Minnesota counties. Platas is examining the regional purchase coefficients and production functions for different sizes of operation. This has been a weakness in earlier studies of the pork industry. Ha's work will be ready for public release in late 1999. Platas's work will be ready for publication in late 2000.

John Leatherman, Kansas State University, is planning to use an integrated econometric/input-output model to evaluate the economic and fiscal impacts of alternative types of livestock operations in Kansas. The project will probably be done in 18 to 24 months.

4. RECOMMENDATIONS FOR ADDITIONAL RESEARCH ON REGIONAL BENEFITS AND COSTS OF ANIMAL AGRICULTURE

Current research does not provide much evidence of the potential economic and fiscal impacts of new feedlots on communities or counties. The net economic impacts will depend upon the current economic structure of the area, the spending patterns of local farmers, and the characteristics and commuting patterns of local labor. The net fiscal impacts will depend on both additional tax revenues, changes in state aid, and additional local expenditures. Only two studies (DiPietre and Watson 1994; Otto and others 1998) tried to measure these changes. However, these estimates are specific to their states and there are some questions on the data. Even in Minnesota, the same industry will have different fiscal impacts on different counties.

To estimate the overall economic benefits of animal agriculture as called for in question #1 of section F, either regional input-output or integrated econometric/regional input-output are the most accurate and practical. Computable general equilibrium models will not give the detail

needed and are very expensive to build. Export base models are inexpensive to build but give no detail. Comparable area and before/after studies can not be used ex ante and have many problems in developing truly comparable areas. But more importantly, with the comparable areas or before/after models, it is difficult to determine the extent to which the changes are due to factors other than feedlots.

However, the input-output and integrated econometric/input-output models will give accurate results only when the data used is accurate and when the impact scenarios are properly defined to include both the impacts on the livestock industry and any potential off-setting effects. An example of an off-setting effect related to the livestock industry would be the reduction in the number of houses built on a new sub-division as a result of a new feedlot. The net effect would be the positive economic impact offset by the negative economic impacts of the loss of the additional housing. This offsetting effect only occurs if the houses definitely would have gone in without the feedlot.

To use integrated econometric/regional input-output models on feedlot issues, additional research is needed on:

1) estimation of the regional purchase coefficients in order to accurately estimate the purchases within a region;

2) examination and verification of the fiscal impact models components of integrated econometric/input-output models.

3) integration of the social impacts work with the fiscal impact analyses;

4) examination of the regional production functions in input-output models;

5) studying the potential off-setting effects and means of accurately defining the impact scenarios;

6) greater collaboration between economists, sociologists, anthropologists, ecologists, and production agriculture scientists in studying the economic, social and environmental impacts of different types of agriculture;

7) practice in using integrated econometric/input-output models in local settings for educational purposes;

8) capture a more realistic regional scale;

9) incorporate a temporal dimension to the economic impact estimates;

10) examine the overall structure of agricultural production in terms of the local economic impacts.

The recommended additional research listed above is necessary if clear conclusions are to be reached on question 1 in section F. The following section provides greater detail on the recommendations.

Discussion of Future Research Needs:

Suggestion one deals with estimates of the regional purchase coefficients. Given the importance of the purchasing patterns on the multiplier effects and the very thin database currently available, additional work should be done to expand on the work of Chism and Levins (1994). . While their work used an excellent methodology, the sample size of livestock farms was very small (12 farms over all types of livestock). The sample size should be expanded greatly so that estimates of purchasing patterns can be determined for different types and sizes of livestock operations.

Two, the fiscal impact models are in their infancy. They need careful examination and verification in a variety of ways, including detailed tracing ex poste of the impacts predicted in ex ante models.

Three, there is a need for integration of the social and fiscal impacts. While sociologists often predict that social program costs will increase with the establishment of large-scale livestock operations, the current fiscal impact models do not adequately incorporate differential growth in public sector costs. The achievement of the third suggestion would require an interdisciplinary team with sufficient budget to do longitudinal studies.

Four, we need to examine the regional production functions in input-output models. As some have pointed out, the data used in I-O models pre-determines many of the results. To improve regional I-O models in this respect will take an interdisciplinary team of farm management economists working with regional economists and a long-term database from farms of different sizes and types.

Five, the development of scenarios in input-output analysis often ignores the offsetting effects. While CGE models automatically capture some of these, I-O models cannot. These offsetting effects can be handled outside the model and entered as a secondary shock.

Sixth, greater collaboration is needed between a wide range of social and physical scientists, industry groups, environmental groups, local governments, and citizens to trace the consequences of different types of agriculture;

Given the many competing research needs, suggestion #6 will only happen if the some state agency invests sufficient funds to create incentives for ongoing focus on these issues.

Seventh, there is a need to practice using existing integrated econometric/input-output models in local settings for educational purposes. While there is much research needed to improve the accuracy of regional models, much could be learned from applying the existing models in educational settings now. If used in the fashion suggested by Barrows (1993) and readily

pointing to the limits of the models, they can help community leaders recognize new questions and frame issues more clearly.

Eighth, the definition of "local" needs to be considered. In prior studies (Chism 1993), local was defined as being within 20 miles of the farm. From the state's perspective, is this the correct definition? If farmers buy inputs 40 miles from their farm but still in Minnesota, the economic impacts on the state of Minnesota are positive even if the sales are lost to vendors within 20 miles. Insistence on buying within 20 miles might be good for one local community but result in higher costs for the farmer as well as hurt another local community. This is an area where policy and research methods overlap. To help sort this out, additional research is needed on alternative definitions of "local."

Ninth, a temporal dimension to the economic impact estimates needs to be incorporated. Nearly all of the impact models estimate the impacts for a year. Some analyses split out the difference between construction and operation (DiPietre and Watson 1994). Few consider the changes over time in the levels of operation. This should be explored.

Tenth, there is a need to examine the overall structure of agricultural production in terms of the local economic impacts. As Dr. Leatherman outlined in his comments, livestock production is changing in both scale and vertical integration. As he points out current research focuses either on specific facilities or industry-wide impacts. It would be useful to do more research on the large integrated systems such as the one he describes of a network of production and processing facilities with 40 confined animal feeding operations and processing for 1 million hogs annually.

Appendix A

Regional Input-Output Models: A Non-technical Explanation

The following extended quote is from the University of Wisconsin-Extension bulletin (Goode 1982) gives a non-technical description of how regional input-output models and multipliers are developed. This was a regional project and Frank Goode is a Professor or Agricultural Economics at Pennsylvania State University. The extended quote follows:[5]

The Transaction Table

The input-output model takes its name from one of the tables typically constructed in such studies. This table shows the distribution of sales of each of the sectors in an area economy to each of the other local sectors and to the export sector. Suppose that we have a rural community in which we can assign each of the firms to one of four sectors: the agricultural sector, the manufacturing sector, the retail sector, or the household sector. The input-output transactions for such a community are shown in Table 1. The first (row) of Table 1 indicates the distribution of total sales of the agricultural sector to the other sections in the local economy and for export. Agricultural production in the region totals $100. Of that $100, sales to other agricultural firms accounts for $5, sales to manufacturing firms for $10, sales to retail establishments, such as grocery stores, for $10; and direct-marketing sales to the household sector for $15. The balance of $60 of agricultural output is exported to individuals and firms outside the region. Conversely, each column of the table represents the distribution of input purchases for each of the four sectors. Thus, the columns of such a table represent the inputs and the rows represent the outputs of the sectors in the local economy. Generally, these flows are measured in dollars.

The Input Coefficient Table

The next step in input-output analysis is to use the information in Table 1 to develop an input coefficient table. The input coefficients for a particular sector indicate the amount of input purchases by that sector, per dollar of output, from each of the sectors. The input coefficients in Table 2 are obtained by dividing the entries of each column of Table 1 by the total of the corresponding row. For example, each of the entries in the first column would be divided by the total of the agricultural row. To produce one dollar's worth of agricultural output requires 5 cents' worth of input from other agricultural firms, 20 cents' worth of inputs are required from the manufacturing sector, 30 cents' worth of inputs from the retail sector, 25 cents' worth of inputs from the household sector in the form of labor, and 20 cents' worth of various imported inputs.

The Multipliers

The next step in input-output analysis is to develop multipliers. There are a variety of multipliers, but those most commonly used reflect the total change in output in the economy associated with a $1 increase in exports from one of the sectors. That is, for an economy such as that represented by Tables 1 and 2 there would be four multipliers. These multipliers would

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[5] This publication is in the public domain and not copyrighted so it can be quoted at length with full citation and without explicit permission.

indicate how much total output in the local sectors would increase as a result of a $1 increase in exports from the agriculture, manufacturing, retail, or household sector. These multipliers are obtained as follows.

Suppose we are interested in finding the multiplier for the manufacturing sector because of an anticipated increase in export demand for that sector's output. This could be reflected in the expansion of employment in an existing firm or the arrival of a new firm. If the manufacturing sector's exports increased by $1, the immediate and so-called *direct effect* is the $1 increase in output in the manufacturing sector. However, increasing output by $1 in the manufacturing sector requires inputs of other sectors. Namely, the $1 increase in manufacturing output requires 6 cents' worth of inputs from the agricultural sector, 3 cents' worth of inputs from both the manufacturing and retail sector, and 44 cents' worth of inputs from the household sector. These increases in output are referred to as the first-round *indirect* effects.

The first-round increases in output require each of the four sectors to increase their input purchases. For example, the first round required agricultural production to increase by 6 cents; thus, the agricultural sector must purchase additional inputs. The increased output of 6 cents in the agricultural sector again required inputs of (only 3/10 of 1 cent from agriculture and) 2 cents from the (retail) l sector, and 1 cent each from the manufacturing and household sectors.[6] Likewise, the first-round increased output of 3 cents in the manufacturing and retail sectors and 44 cents in the household sector requires additional inputs from the other sectors. The inputs required to support the first round are referred to as the second-round *indirect effects* and are found in Column 3 of Table 3. That is, to support the first-round impacts listed in Column 2 of Table 3 requires 5 cents' worth of input from agriculture, 4 cents from manufacturing, 25 cents from the retail sector, and 4 cents from the household sector. The round-by-round procedure continues until the magnitudes are so small as to be negligible. Summing all of the rounds yields the amount that output I each of the four sectors would increase in response to the original $1 increase in manufacturing-sector exports would require increased output of approximately 16 cents in the agricultural sector, $1.12 in the manufacturing sector (this includes the original $1 increase in demand), 45 cents in the retail sector, and the total income of the household sector, would increase by about 67 cents. In total, the entire economy will increase by $2.40 in response to the original $1 dollar increase in export sales of the manufacturing sector. Put another way, each dollar increase in export sales from the manufacturing sector generates an additional $1.40 worth of business in all four sectors in the economy. The multipliers for all of the sectors are shown in Table 4.

[6] The interested reader is referred to William M. Miernyk, The Elements of Input-Output Analysis for a full description of the mathematics. Goode had an error in this sentence. His numbers in Table 3 are ok but this sentence had a math error. We've corrected that for ease of exposition.

Table 1: Transaction Table for an Area Economy*

Economic Sectors	Agriculture	Manufacturing	Retail	Household	Export	Total Sales
Agriculture	5	10	10	15	60	100
Manufacturing	20	5	5	10	140	180
Retail	30	5	5	90	15	145
Household	25	80	30	10	25	170
Imports	20	80	95	45		
Total Expendes	100	180	145	170		

Table 2: Input Coefficients for an Area Economy.

Economic Sectors	Agriculture	Manufacturing	Retail	Household
Agriculture	.05	.06	.07	.09
Manufacturing	.20	.03	.03	.06
Retail	.30	.03	.03	.53
Household	.25	.44	.21	.06

Table 3: Direct and Indirect Effects Associated with a $1 increase in Manufacturing Exports.

Economic Sectors	Direct	Indirect Rounds*			
		(1)	*(2)*	*(3 to 13)*	*Total*
Agriculture		.06	.05	.05	.16
Manufacturing	1	.03	.04	.05	1.12
Retail		.03	.25	.17	.45
Household		.44	.04	.19	.67
				Total:	2.40

*While Goode's article shows indirect rounds 3 and 4, the typical input-output model uses the equivalent of 13 indirect rounds. The total impact of these indirect rounds is shown above even thought Goode left them blank in table 3 even though it is clear from the text that they must be calculated. We add them for clarity.

Table 4: Direct and Indirect Requirements (Sector Multipliers).

Economic Sectors	(1) Agriculture	(2) Manufacturing	(3) Retail	(Ha and Morse 1998) Household
Agriculture	1.18	.16	.13	.19
Manufacturing	.30	1.12	.09	.15
Retail	.71	.45	1.28	.81
Household	.61	.67	.36	1.36
Total	2.80	2.40	1.86	2.51

Reviewer Reports, CAC Questions, and Responses to Them

Response to Comments by Dr. Julie Bunn by Carl V. Phillips

General Comments, paragraphs 1 and 2

There is nothing here the calls for a direct response. I appreciate Dr. Bunn expressing agreement with the editorial decisions, particularly the decision to not report specific numbers.

Definitions of Real vs. Pecuniary Costs; External vs. Internal Costs and Benefits; Local

The recommendation to clarify these in the report is well taken. There are now new sections in the general introduction of the document that present these more explicitly. I have added Dr. Bunn's observation about the policy (rather than scientific question) about whether external impact outside Minnesota should be considered in the analysis to the discussion of further research.

More attention to distribution (from parts I and II of the comments).

These are good points, and I have received similar suggestions from other sources. Distributional issues are extremely important for the GEIS (and most externalities questions), and the lack of conclusions about them in this report does not imply they are unimportant -- just that they are difficult to pin down. As Dr. Bunn notes, there are references to distributional issues throughout the report, and no further detail has been added.

If I had the whole report to do over again, I would start with the notion of distribution and work from there treating totals as subsidiary, rather than the other way around. I have added a discussion of this in the new discussion under "Critique of Study Questions" near the top of the report. Basically, the presentation of the questions steered the research in a direction that, in retrospect, was not optimal, but this was not obvious to me until it was completed and the time constraints make a broad rewrite impossible. As Dr. Bunn notes, the literature cited involves many discussions of distribution. Since none of them relate to specific animal agriculture analyses (beyond the obvious, such as property value impacts affecting local homeowners), and since I was emphasizing totals first, I did not make an effort to highlight the distribution discussions. They certainly should be part of any further research in the area.

Other methodologies.

I have added a more explicit discussion of alternatives and mitigation costs under market valuation methods. Many other methods should be considered in the GEIS process, but I have left them out of the background discussion in the interests of brevity.

Variation of Impact by Size and Type of Facility

The suggestion that an analysis of how external impacts of facilities vary in general, even though no information is available on animal agriculture facilities specifically, is a good idea that did not occur to me. I did not look specifically for such analyses (e.g., of different sized industrial facilities or of cropland versus industrial facilities). The undoubtedly exist, but I cannot comment further. Similar to the above, I would have done this from the start if I had thought of it and had time, but cannot add anything given the time constraints. I suggest that anyone doing

further research on valuing externalities in the GEIS consider this as a potentially useful direction to go in.

Response to Comments by Dr. Paul McNamara by Carl V. Phillips
I appreciate Dr. McNamara's comments and have relatively little to say in direct response.

Relative Size Questions
A discussion of the size of externalities from animal agriculture compared to other sources of, e.g., water pollution, could provide useful perspective and context. Since the Scoping Document did not ask for such a comparison, it is largely absent from the report, though there are hints of it in the discussion of why we value costs and benefits, and the use of substitution costs as a valuation method. The specific question of which method is cheapest for achieving a desired goal is at the heart of cost-benefit analysis, and should be taken up in any further research on valuing externalities.

Care must be taken in making the suggested comparisons to avoid using them to "prove" that the effects of animal agriculture are large or small, depending on the politics of the analyst. I suspect that for this very reason, the EQB did not ask for such comparisons to be made in these reports (and I suspect that in many cases where they are made, readers of the reports will detect bias).

Response to Questions from the CAC by Carl V. Phillips
Clarify the recommended future studies on costs? Why are there not recommendation regarding research on benefits?
More detail has been added to the recommendations since the draft. The question about benefits referred to the emphasis on costs in the spillover/pollution half of the report. This is just a matter of the most convenient semantics. As noted in the introduction, it is impossible to formally distinguish a study of costs from a study of benefits. Implicit in every statement about something creating a cost is a statement that action to eliminate the impact would create a corresponding benefit.

What would be the cost of some of these recommended de novo or CV studies?
Since cost of studies was not part of the Scoping Document questions and is not otherwise reported, I am answering this here but not adding it to the report. My estimate, based on some numbers that Pat Welle gave me from his work, is that a sufficient CV study to answer one of the big questions would cost in the range of $75,000 to $100,000. Multiple studies could be carried out by the same researchers for less than that amount per question being answered.

Explain the methods and size farms studied by Taff and Palmquist.
More detail has been added to the discussion of these papers. If further detail is desired, the full papers have been included as "key articles."

Clarify the known impact of large facilities on property values.

Beyond the discussion of Taff et al. and Palmquist et al., there is nothing more to add on this subject from the literature. We cannot clarify the known impact, because the impact is not known.

It seems that the "screen" for including research or explaining research was different in this report. How was the decision made in these two cases?
In the spillover/pollution section, every report known to the authors that directly relates animal agriculture to the value of an externality is mentioned. Some details are presented for all but one, I believe (the remaining one was identified as hopelessly flawed, and is in an area that is tangential anyway). Of the thousands of papers that address part of the question but do not cover the full relationship, I selected some of them to emphasize what exists, but made no attempt to present a full picture (as noted in the report). Of the literature that provides background and justification for particular approaches and observations, I attempted to present what exists and identify places where there are substantial substantive disagreements in the literature.

In terms of this report being different from others (or the two halves of this report being different), I suspect in reality the differences are only in the readers' perception based on a few comments, not the reality. Every secondary researcher, including those who wrote this report and those who wrote the other GEIS reports, makes decisions about what to mention, what to discuss in detail, and what to leave out. (In my experience teaching people how to make sense of technical literature, most people do not realize this and find the news quite disturbing.) Even in a literature review, which is theoretically a more judgment-free form of secondary research, screening will occur. Both halves of the externality report actually probably do much less screening than the other reports, since they report all of the very short list of relevant studies while the other reports had to choose from hundreds or thousands, unable to discuss them all. To the extent that the Externalities report appears to do more screening, it is probably because it explicitly mentions the relatively few places it was done.

Caution about drawing conclusions regarding animal well-being in the report.
I do not recall what question or discussion at the meeting led to this directive, so I cannot answer in detail. In rereading both the submitted draft and the final version, I cannot figure out where the report can be said drawing conclusions about animal well-being. The report makes the obvious observation that agricultural practices affect animal well-being, and discusses the literature on how people value such well-being. The only real conclusion in this section is not about animal well-being per se, but about people's values: people's values for animal well-being are real economic externalities (and substantial, according to available data), a conclusion that any economist who studies cost and benefits would agree with (setting aside more complicated questions about incorporating the animals' values themselves, which would provoke disagreement).

Distribution of costs and benefits -- What does the literature tell us about this distribution particularly who pays?
See the discussion in the response to Dr. Bunn's comments and the reference addition to the report.

Differences between the human health, animal health and externalities report -- Address the conflicting statements.
I offered contributions to both the Human Health and Animal Health reports that reflected the underlying (and fundamentally undebatable) facts presented in the Externalities report, and they have been incorporated to some extent. To the extent that differences remain, I stand by what is contained in the Externalities report. I am sufficiently expert in both of these areas to be confident that my conclusions reflect the overwhelming weight of the evidence and the opinions of most unbiased research in the fields.

Regarding animal health and well-being, as mentioned two questions previous, the conclusions are only about how members of the public are adversely affected by the treatment of the animals. This is completely uncontroversial from an economic perspective, and there is no question that many people in our society are not happy with farm animals' well-being and are willing to pay to improve it. Implicit in that discussion is that people's opinions about what is acceptable and what is wrong matter, which is also fairly non-controversial in our society. To the extent that there is an apparent conflict with the Animal Health report, I believe it is because the first draft of that report focused on the industry's claims that existing levels of animal well-being are acceptable. The final version of the Animal Health report has toned down that claim somewhat, and has added my observations that the public, politics, and moral philosophy determine what is ethically acceptable in our society, not the industry or veterinary researchers. To the extent that there still appears to be a conflict, I strongly defend the analysis presented in the Externalities report as both correct and not controversial among unbiased experts.

Regarding human health, I interpret the question to refer to the healthfulness of eating animal foods, since there was general agreement on most topics covered in the Externalities report, specifically water and air pollution, foodborne illness, and antibiotic use. (Some aspects of occupational health were not discussed in the Human Health report.) The Human Health report now agrees that the impacts of nutrition are beyond the scope of the GEIS. That report now also leads off the discussion of nutritional effects by noting that public health research overwhelmingly shows that eating less animal food is healthier, despite the to-date incomplete results from biochemistry that were emphasized in the draft of that report.

Opinion Polls -- Please explain the basic methodology behind the cited opinion polls.
A bit more detail has been added to the endnote that discussed the poll. The press releases and a brief overview about the results is included in the collection of key articles. (Unfortunately, further details from the polls are proprietary, and cannot be presented.)

Clarify why economists are only interested in the extra or surplus cost?
Per the discussion of Dr. Bunn's comments, the report has been expanded to further clarify the point.

Response to Outside Reviewers Comments for Regional Economics Section of Externalities Report by George W. Morse and Steffanie Guess-Murphy

Reviewer: Dr. Larry Leistritz, Professor of Agricultural Economics, North Dakota State University

Dr. Leistritz's comments are very complimentary. He points out that while we addressed the questions thoroughly, "the literature simply does not include much evidence on some topics."

Dr. Leistritz was selected as a reviewer because he is President of the International Association of Impact Analysis and has written extensively on regional economic impact analysis.

Reviewer: Dr. John Leatherman, Department of Agricultural Economics, Kansas State University

Under "General Comments," Dr. Leatherman reinforces our caution to be skeptical of claims of economic benefits. We discuss this as offsetting effects.

Question 2: While Dr. Leatherman rates our discussion of the research as "quite good," he would prefer additional verbal or tabular summaries. Time did not permit the addition of tabular summaries. Compared to the draft he reviewed, we have added verbal summaries to the major sections of the report.

We agree with his observation that there is a need for greater integration across the sections. Based on his comments, we did revise the document in several places to provide reference to the work of others.

Question 3: We agree with Dr. Leatherman's suggestion for additional research. His second and third paragraphs provide support for the suggestions that we included in our original draft. We have added three additional research suggestions that he made which we did not have in our original draft.

We strongly concur with his suggestion that research on this should be done on a multi-state level. A coordinated multi-state level effort for the new research would make it possible to tackle many more of these issues.

Dr. Leatherman is Director of the Office of Local Government Affairs at Kansas State and highly respected for his public policy work.

Response to Citizen's Advisory Board Comments on Externalities Topic on Questions Related to Section II on Regional Economics by George W. Morse and Steffanie Guess-Murphy

Needed Research:
"Explain the recommendations in the regional economics section. How do these relate to the GEIS?" These are related to question 1 in Section F of the RFP. The introduction of the second paragraph was changed to clarify this. Two sentences are also added after the list of specific items to clarify this connection.

What do we know about the community effects of different size farms?
"Clarify explanation of the size impacts on local buying patterns and buying level." This is dealt with in section II.2.2.3 "Purchased Supplies" under the sub-heading: "Purchased Supplies by Location of Purchase." A summary statement is added at the end of this section to provide clarification.

"Explain the misunderstanding and understanding about the recent Iowa State Study on this question." The Iowa State study on the impacts of different sizes of pork operations (Otto and others 1996; Otto and others 1998) did not adjust the level of input purchases by farm size. As outlined in the original report, the Otto, et al. papers found that larger pork operations had more positive economic impacts than smaller ones. As Thompson and Haskins (1998) point out the Otto, et al. papers should have set the total level of output equal before making an comparison but did not. When this is done, the smaller farms appear to have the advantage in terms of number of jobs but the disadvantage in terms of the quality of those jobs (i.e. income per worker). However, the Thompson and Haskins analysis fails to consider the survival rate of different sizes of farms. If larger pork farms are more likely to survive than smaller ones, as Otto, et al. suggest, then the economic benefits of large farms are likely to be larger than the small ones.

"*What are the effects of one big buyer on a local economy?*" If the one large buyer had a "buyer's monopoly," it is called a "monopsony." Assume it had a buyer's monopoly on both labor and livestock. Then it would pay lower wages than it would if it was a perfectly competitive buyer. And it would pay lower prices for the livestock than if it was in a perfectly competitive market. No studies were found that addressed the question of whether monopsony conditions existed in either or both of these markets. However, while this is an excellent question, it was not raised in the scoping document and was not explicitly addressed in the literature search. If this question is of particular interest to the CAC/EQB, it could be addressed in future research.

"Is there general agreement on the conclusions drawn?" The conclusions drawn on this issue do not attempt to extend those reported in the literature reviewed. The two outside reviewers did not find the conclusions drawn to be inaccurate. Without expanding the formal review to additional economists, it is difficult to conclude whether others would agree with these conclusions. Since we kept very close to the literature cited, we fully expect that they would.

Report contents

"It seems that the 'screen' for including research or explaining research was different in this report. How was the decision made in these two cases?" I understand that this question relates to the last paragraph under the section entitled: "Focused on Facts not Value Judgements" in the Executive Summary. In that section we stated that we did not provide as much detail on the results and conclusions of the studies which had major flaws in their research methodology (although we did cite them and reported on their methodology and discussed the methodology).

While other sections might not have explicitly stated this screen, I am certain that most if not all used exactly the same screen. If a section did not, they are not being responsible in evaluating the validity of the scientific merit of the work reviewed. All research studies are not created equal. Some have major flaws and their conclusions should not be "averaged" in to the mix as if they were done correctly. Economists often disagree on policy matters, and naturally, there are often debates on research methods when dealing with new cutting-edge issues. However, there is a large body of agreement on good research methods. If no evaluation of the scientific merit was desired, then the literature review could have been done by a team of undergraduates at a much lower cost. I assume that the reason that the EQB wanted to have faculty directly involved in all phases of this study was to ensure that critical professional judgments were made on the validity of the research methods used. We have done that in this section. In contrast, we have not taken sides on the policy issues. These critical policy issues must be made by the CAC/EQB and other policy makers.

"What is the status of outside reviewer comments?" These are attached.

Impact on Local Government Spending

"Is there a known or hypothesized impact on local government spending as a result of migrant workers or lower paying jobs related to animal agriculture?"

Any social scientist can hypothesize the impacts which migrant workers or lower paying jobs will have on local government spending. But the question is whether or not these hypotheses are correct. For this, we would need empirical evidence. The research on local government spending related to livestock operations did not address this. To our knowledge, no systematic study of this exists. However, the scoping document did not ask this question and we did not explicitly do a literature search on it. Consequently, we are uncertain if there is any empirical research on this question.

"What about the known impact on roads?" None of the fiscal impact studies explored this issue in depth. DiPietre and Watson (1994) included an estimate of the amount that Premium Standard Farms paid to local governments to rebuild roads damaged by construction traffic. This clearly suggests that there is some impact. Further research is needed to more clearly document the level of this impact.

"Is there general agreement on the conclusions drawn?" As pointed out in the Executive Summary under the "Regional Development Section," there have been only a very limited number of studies on the impacts of animal agriculture on local government spending and

revenues. Consequently, we cautioned readers that there was a need for much additional research attention to this issue. We reaffirm this.

Distribution of Costs and Benefits

"What does the literature tell us about this distribution, particularly who pays?" The methodologies used in the regional economics section focus on "benefits" and could only track costs if they are captured in local government expenditures. If the net local government fiscal impact is negative, then local taxpayers share these costs. If the net local government fiscal impact is positive, then the local taxpayers benefit. To date, the limited number of studies have shown positive fiscal impacts. As mentioned earlier, this work is in its infancy and caution should be used about drawing conclusions.

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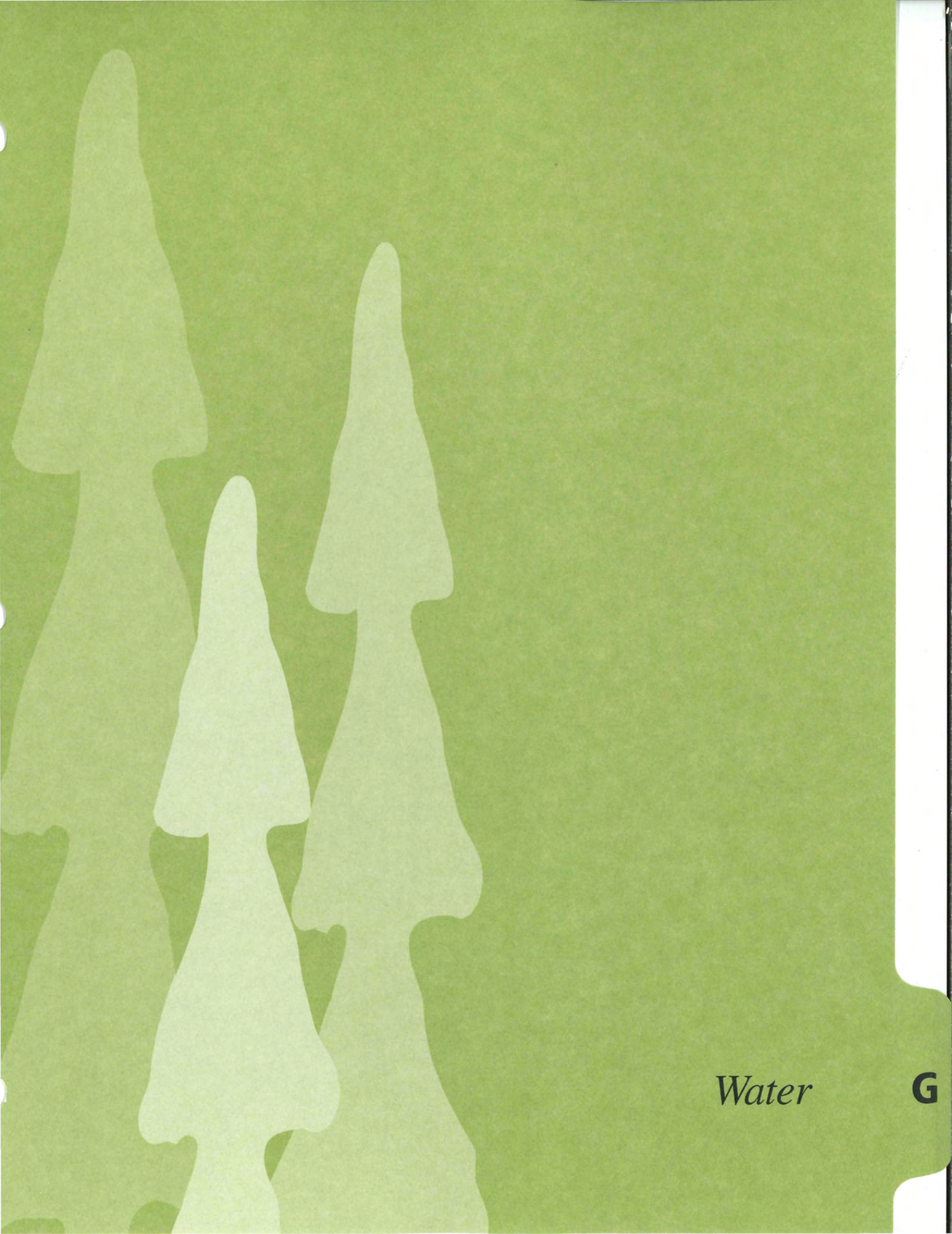

Water **G**

Generic Environmental Impact Statement on Animal Agriculture:

A Summary of the Literature Related to the Effects of Animal Agriculture on Water Resources (G)

Prepared for the Environmental Quality Board

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EXECUTIVE SUMMARY

Surface and ground water are precious resources to be protected from various types of pollution arising from animal agriculture. Surface waters can be degraded by excess nutrients (nitrogen and phosphorus), pathogens, and oxygen demanding organic materials. Nutrients and oxygen demanding organic materials in excessive quantities can lead to eutrophication and diminished oxygen levels in water, as measured by dissolved oxygen. Ground waters can also be degraded by excess nutrients and pathogens. The extent of water quality degradation from less well studied substances in animal manure such as heavy metals and hormones is unknown.

Degradation of surface water quality can arise from various types of problems associated with poor management of animal operations. These include surface runoff from feedlots, spills from manure storage lagoons, tile drain effluent from lands receiving excessive manure and fertilizer applications, leaching losses from lands receiving excessive applications of manure and fertilizer, and seepage of manure from waste storage lagoons. Degradation of stream water quality, aquatic habitat, and riparian habitat can occur when grazing operations are poorly managed.

In this report, we were asked to answer ten scoping questions relating to the impacts of animal agriculture on water resources. We reviewed the recent literature published in scientific publications to formulate an answer to these questions, and identify research needs where insufficient knowledge was available to provide an answer. In the summary below, our main conclusions from this study are presented for each of the ten scoping questions.

1. To what extent are groundwater and surface water affected by or at risk from animal manure storage, handling, and application?

Some of our main findings in this report with respect to pollution of surface streams by animal operations include the following:

- Livestock waste can contribute significantly to phosphorus loads in surface waters (7-65% of total load), although another major source is non-agricultural land (especially municipal waste water treatment plants). Livestock waste usually contributes less significantly to nitrogen loads (15-37% of total load). However, the primary source of watershed impairment by nitrogen is from fertilizers.

- Nutrient losses per unit area in runoff can be greater in magnitude from croplands, manured croplands, and grazed pastures than from rotationally grazed lands, forest lands, or natural prairies. Losses from well managed cropland or grazed pastures are usuallysmall and are comparable to the small losses observed on rotationally grazed lands.

- Critical areas for phosphorus loss to streams and lakes are typically those areas high in soil available phosphorus in close proximity to waterbodies.

- Feedlot runoff contains extremely large loads of nutrients and oxygen demanding substances, and if not properly collected and prevented from entering surface waters, this runoff can severely degrade surface water quality.

- Fecal bacteria concentrations in surface waters from manured lands are often not significantly different from pathogen levels in surface waters from unmanured lands if the manure has been stored and aged before land application. Natural wildlife can also be a significant source of fecal bacteria leading to surface water quality degradation.

- Fecal bacteria in surface waters from lands receiving fresh manure applications can be a significant proportion (over 80%) of the fecal bacteria carried in surface waters. Where illegal discharge of septic tanks to surface waters occurs, human waste can also be a significant source of pathogens in surface waters.

- The most significant components of pollutant losses in surface runoff from manured lands are for ammonium, particle-bound and soluble phosphorus, and oxygen demanding organic materials. Nitrate-nitrogen is rarely a significant contaminant in surface runoff.

- Nutrient losses in runoff from manured or fertilized fields are typically much greater than losses from unmanured or unfertilized control plots.

- Nutrient losses in runoff increase with the rate of manure or fertilizer applied.

- Losses of nitrogen and phosphorus in runoff from manured versus fertilized fields are not significantly different if the manure and fertilizer are applied at equivalent rates of nitrogen content.

- Nutrient losses in runoff from manured fields decrease when manure is injected or if manure is stored for several weeks before land application.

- Nitrogen losses in runoff from manured fields are least when manure is applied in spring (especially late spring), and greatest when manure is applied in fall.

- Nutrient losses in runoff from manured fields increase when the time between land application and rainfall is brief, especially for intense rainfall events.

- Nutrient losses in runoff from manured fields are usually excessive when land application to snow or frozen soils occurs.

- Losses of phosphorus in runoff are generally greater when manure is applied to corn rather than alfalfa or grass, but can be negligible when erosion and runoff are controlled on corn fields using conservation tillage. In comparison, phosphorus losses in runoff from manured corn are generally greater than losses from natural prairie, woodlands, and forest lands.

Surface water impairment from pathogens is a great problem in most rural areas of southern Minnesota, which causes many rivers and lakes to be unsuitable for swimming. Research on fecal bacteria transported in runoff from manured lands shows that:

- There are typically no significant differences in fecal bacteria levels in surface runoff from manured versus unmanured or grazed versus ungrazed lands. This is due to fecal bacteria from natural wildlife, and die-off of bacteria in manure after storage or land application.

- Rate, method, or timing (spring versus fall) of manure application has little effect on fecal bacteria counts in surface runoff.

- Fecal bacteria counts in surface runoff are significantly greater after application of manure to snow or frozen soil than after application at any other time of year.

Large areas of Minnesota are poorly drained and have artificial tile drainage installed to improve soil productivity. The major factors which influence losses of nutrients through tile drains include rate of application, timing of application, form and method of application, tillage, and cropping system. The literature on nutrient losses through tile drains shows that:

- The most significant contaminant in subsurface tile drain effluent is nitrates. Soluble and total phosphorus losses are generally negligible in comparison to their losses in surface runoff. Losses of ammonium and oxygen demanding organic materials are generally lost in much smaller quantities through subsurface tile drain effluent than through surface runoff.

- Nitrate losses in subsurface tile drainage increase with the rate of manure or fertilizer applied, unless very high rates of manure are applied on wet soil, when denitrification reduces the losses of nitrogen. Nitrate losses in tile drains from manured fields are typically less than or equal to losses from fertilized fields receiving equivalent rates of nitrogen.

- Liquid manure applications cause more risk for nitrate leaching to subsurface tile drains than surface applications of solid manure, especially when liquid manure is injected.

- Manure applications to continuous corn will typically cause greater losses of nitrate-N in subsurface tile drainage than manure applications to other crops, all other factors being equal.

- Losses of phosphorus through subsurface tile drainage systems are typically negligible, unless very high rates of manure are applied, or the soil test phosphorus levels have built up to excessive levels.

- No research on the impact of surface tile inlets on nutrient losses from land application of manure through tile drainage systems has been published in peer reviewed journals.

Catastrophic spills from large manure storage facilities can occur primarily through overflow following large storms or by intentional releases. A third mechanism, collapse of a

sidewall is less frequent, and has never occurred in Minnesota. A review of scientific literature shows that spills from manure storage basins have the following characteristics:

- The impacts on surface water quality and aquatic life from manure lagoon and storage basin spills, feedlot runoff, and applications of manure to frozen ground can be devastating.

- The number of documented serious water quality pollution problems involving manure lagoon spills and feedlot runoff is generally several tens of events per year in each of the states with high concentrations of feedlots.

- Compared to the several thousands of feedlots in most states, the number of water quality pollution problems causing documented fish kills from lagoon and basin manure spills and feedlot runoff is typically a small fraction of the total number of operations.

Numerous studies have been conducted to determine the impacts of animal agriculture on ground water quality. These studies show that many factors influence contamination of ground water by nitrates or fecal bacteria. These factors include:

- Depth and condition of the well,
- Type of soil and geologic material above the aquifer,
- Location of the well,
- Land use surrounding the well (particularly cropland),
- Density of animals and manure handling and application practices, and
- Type of lining on manure storage systems.

Ground water contamination from animal agriculture is most likely to occur when intensive animal agriculture occurs in regions having coarse textured soils, shallow ground water, and heavy precipitation. Lined manure storage basins and lagoons which are properly constructed, engineered, and managed are generally not a serious threat to ground water quality, unless constructed in coarse textured soils or karst terrain. Unlined earthen manure storage systems generally pose a much greater risk for pollution of ground water by seepage than lined storage facilities.

2. **How do the effects or risks (from #1) affect the use of water by humans for drinking, recreation, and other purposes?**

Drinking water can be contaminated by pathogens and nitrates arising from animal agriculture. It is estimated that up to 900,000 illnesses and 900 deaths occur each year from waterborne microbial infections, but the source of contamination in these instances is not known. There have been 14 documented incidents of cryptosporidium disease outbreaks in U.S. and Canada since 1984. Four of these events were linked to nonpoint source agricultural pollution, the others were primarily caused by septic tank and human sewage contamination.

It is estimated that roughly 7% of the 450,000 private drinking water wells in Minnesota have nitrate-N levels exceeding the maximum contaminant level (MCL) of 10 mg/L. There are another roughly 1,700 public community water supply wells in Minnesota, of which roughly 1% have nitrate levels greater than the MCL. The percent of these contaminated wells that are affected by animal agriculture is unknown.

Nationally, it is estimated that 36% of rivers and streams, or 39% of lakes are impaired, meaning that they did not support or could not attain the goals and standards set forth in the Clean Water Act and state regulations. The primary cause of impairment in 70% of the rivers and streams classified as being impaired was agriculture. Of these agriculturally impacted rivers and streams, non-irrigated cropland production was the leading cause of impairment (36%), followed by irrigated cropland production (22%). Other causes of impairment were rangeland (12%), pastureland (11%), feedlots (8%), animal operations (7%), and animal holding areas (5%).

In Minnesota, about 60% of the surveyed or monitored rivers and streams, and 17% of the surveyed or monitored lakes were classified as being impaired. Agriculture was identified as the cause of 90% of the impaired river miles, and 64% of the impaired lake acres. It is unknown to what degree various types of agricultural activities (cropland, feedlots, rangeland, etc.) caused the impairment. In the Minnesota River basin, it is estimated that from 50-100% of the assessed tributary river miles in the Minnesota River basin do not adequately support aquatic life. This results in reduced diversity of fish and other aquatic life, and predominance of undesirable fish species. None of the tributaries is fit for swimming, primarily because of high levels of fecal bacteria.

3. **How do the effects or risks (from #1) affect fish and wildlife (such as fish kills due to pollution)?**

There are many reports in the literature which suggest that well-managed livestock grazing is compatible with a healthy riparian ecosystem but the impacts of specific practices depend on site characteristics. The negative impacts of livestock grazing on stream and riparian ecosystems are widespread in the western U.S, but relatively little is known about grazing impacts on stream and riparian ecosystems in the midwestern U.S.

The negative effects of cattle on habitat for fish and wildlife can include:

- An increase in streambank erosion, reducing habitat availability for both terrestrial and aquatic animals.
- A decrease in large woody debris habitat in and near the stream channel in grazed areas.

Macroinvertebrates are a very important component of the food chain in streams and lakes. Macroinvertebrates, primarily insects, are a highly diverse community, they are indicators of ecosystem biodiversity, they serve as fish food, they perform a wide range of ecosystem functions such as energy and nutrient cycling, and they are valuable indicators of ecosystem health. The negative impacts of livestock grazing on macroinvertebrates can include:

- Reduced terrestrial and aquatic invertebrate densities in streams, especially in small streams.

Fish are quite susceptible to the impacts of poor management in animal agriculture. A few serious incidents of feedlot runoff, manure spills, and runoff from manure on frozen ground can lead to the death of thousands of fish. It is widely believed that many fish kills are undocumented, and there is no comprehensive record keeping mechanism for tracking the number or magnitude of fish kills. At least two agencies have responsibility for responding to fish kills but fish kills are not regularly recorded and reported.

The impacts of grazing on fish are largely based on extensive research conducted in the western U.S. These studies show that:

- Grazing negatively impact fish populations, based on very weak or flawed experimental designs.
- In only a very few cases are there data describing impact to the overall fish community, and those data are inconclusive.

The impacts of poorly managed livestock grazing on birds can be mixed. The literature on this topic shows that:

- Livestock grazing often reduces canopy density and therefore habitat for riparian birds. That in turn reduces densities and diversity of some passerine species.
- Some birds excel in the more fragmented riparian habitat that results from grazing and that same pattern is true for many species which rely on grassland habitats.
- Shorebird populations (especially coastal species) appear to be positively impacted by low levels of grazing; it is not clear that the same responses would be shown in Minnesota waterbirds.

- No evidence suggests that waterfowl are negatively impacted by livestock although those waterfowl are dependent on aquatic invertebrates and may be secondarily impacted by changes in food availability.

Grazing can be a useful tool to enhance wildlife habitat. However, grazing must be carefully managed to control the frequency, intensity and timing of livestock access to insure compatible use with wildlife. Improved livestock management will facilitate more streamside vegetation and increase the abundance and diversity of terrestrial habitat.

4. **What are the health risks to humans from contamination of ground and surface waters from animal manure storage, handling, and application?**

There are basically two types of risks in drinking water which are related to animal agriculture, excessive nitrate levels and pathogens. Nitrate is a common contaminant found in many wells in Minnesota. It has been known since the mid-1940s that too much nitrate in drinking water can cause serious health problems for infants. Roughly 7% of drinking water wells in Minnesota exceed the Maximum Contaminant Level set by EPA for nitrates in drinking water. Drinking water contamination can occur from nitrogen in fertilizer, septic tank seepage, and animal manure.

Fresh animal manure contains a variety of microorganisms which may be pathogenic to man and/or animals. The major types of pathogens include bacteria, viruses, parasite eggs, protozoa, and fungi. The potential of disease transmission from land application of animal manure depends upon:

- The number and viability of microbial pathogens in manure, which in turn depends upon the type of treatment it has received.

- The survival of pathogens for a sufficient period of time and in sufficient numbers.

- The entry of these pathogens into waters and their subsequent ingestion through the mouth as a result of drinking or swimming.

It is unknown whether coliform indicators should continue to be considered as the best indicator of surface water contamination by pathogens for the following reasons:

i. new pathogens have been recently discovered (viruses, anti-biotic-resistant bacteria, etc.);

ii. new information shows that some pathogens have very different viability capacities than coliform bacteria; therefore the latter may not be a very good representative any longer.

5. **To what extent are surface waters affected by or at risk from allowing pastured animals (primarily cattle) access to surface waters?**

Unmanaged grazing has many negative impacts on streams and their nearby landscapes. Heavy grazing reduces vegetative cover, compacts the soil, reduces infiltration, increases runoff, erosion and nutrient and sediment yield. In riparian zones, trampling the streambanks decreases erosional resistance of the streambank and contributes to sediment yield, while vegetation removal increases solar insolation and leads to higher stream water temperature. Excrement deposited either in the uplands or directly into waterbodies can lead to elevated levels of pathogens. Fish and aquatic invertebrates are sensitive to sediment input, water temperature and excess algae and plant growth due to nutrient input. In contrast, low or moderate grazing have effects that are much less significant than heavy or unmanaged grazing.

More specifically, unmanaged grazing has the following effects on sediment production:

- Sediment yield increases with increasing grazing pressure, with the lowest levels of erosion occurring in ungrazed or Aretired@ riparian areas.
- Fine textured soils are more susceptible to trampling effects than coarse textured soils.
- Soil loss increases on steeper slopes.
- Associated with changes in erosion are changes in stream channel morphology. The main effects of unmanaged grazing include:
- Development of unstable channel morphology and the loss of fish and invertebrate habitat.
- Stream channels along heavily vegetated areas are deeper and narrower than along poorly vegetated areas which have been over-grazed.

Unmanaged grazing can also increase the mean stream temperature and the extremes of temperature experienced by aquatic organisms. Relatively small changes in stream temperature can shift aquatic communities from more desirable to less desirable species. An increase of less than 4 degrees Fahrenheit is often sufficient to cause such shifts, and increases in stream temperature of from 4 to 9 degrees F are common when streamside vegetation is removed by grazing.

Finally, unmanaged grazing can cause excess nutrients to enter adjacent streams. In general, nutrient concentrations in runoff increase with increasing grazing intensity.

6. **How do the various impacts in #1 to #5 vary by species, operation, system type, management, geography, geology, watershed characteristics, and concentration of livestock facilities?**

Minnesota has a wide range of characteristics in soil and geologic sediment properties, hydrogeology and climate, and patterns in runoff and erosion. Each of these factors strongly influences the potential for pollution of surface and ground waters by animal manure and animal operations. State-wide patterns in degradation in river water quality as reflected by monitoring data for oxygen demanding substances, fecal bacteria, dissolved oxygen, and total phosphorus vary dramatically among the major basins in Minnesota. State-wide patterns in degradation of lake water quality as reflected by monitoring data for phosphorus, water clarity, and algae vary significantly among the major ecoregions of Minnesota. State-wide patterns in degradation of ground water quality as reflected by monitoring data for nitrates vary primarily in response to soil and sediment properties.

Geographic distributions of cattle, hog, chicken, and turkey population densities in Minnesota are presented in the report. Animal population densities are compared with European limits on animal density, and with geographic distributions of degradation in river, lake, and ground water quality. The following conclusions can be drawn from these comparisons:

- In some instances, crude visual comparison of geographic patterns in degraded ground water quality appeared to resemble patterns in cattle population densities. This does not prove that animal operations caused the water quality degradation. Areas with large human population densities also coincided with areas having degraded ground water and lake water quality. Further study is warranted of these relationships.

The concentrations of nitrate in ground water vary considerably across the state of Minnesota. Inputs of nitrate from agriculture have clearly impacted areas of the state where high-intensity agriculture has been practiced, particularly in the geologically sensitive areas, including:

- The karst area of southeastern Minnesota,
- the sand plains (glacial outwash areas) of Central Minnesota,
- areas of alluvial sands (deposited by old meandering streams), especially those in southwestern Minnesota,
- other areas with enhanced surficial permeability (such as scattered sand and gravel deposits), where rural residents often use shallow sandpoint wells for their drinking water.

- No clear geographic relationship between degradation of rivers or lakes and animal population densities was observed used crude visual comparisons. Further study is warranted of these relationships.

- As size of animal operations increases, the nutrients available for loss to the environment also

increase. This is mainly due to a lack of proper land area for spreading manure. The critical density of animals depends upon the type of animal, and the methods used in storing, handling, and applying manure to cropland.

- As the density of animals in a watershed increases, there is an increasing impact on surface water quality. This is primarily due to increased nutrient production in manure, and inadequate crediting of manure in nutrient applications to cropland. The critical threshold density depends upon the type of animal, the region and its characteristics, and waste storage, handling, and application methods.

- Animals located where their waste has a direct pathway for runoff losses to surface waters have a much greater potential to degrade water quality than animals located away from these direct pathways or on pasture land.

- Minnesota animal densities do not appear to be above the critical threshold levels set for animal operations in Europe. Further evaluation of this issue is needed, because county-wide average animal densities may be considerably different than densities for individual animal operations.

- Blue Earth county conducted a comprehensive evaluation of each and every one of the 886 feedlots in the county. The primary pollution hazards were unlined earthen basins (mostly for swine operations) and runoff to surface water (mostly for cattle operations). A total of 49 feedlots (10% of the active feedlots) were identified as pollution hazards, of which 18 had unlined earthen basins, and 30 had runoff hazards. There is a tendency in Blue Earth county for small sized feedlots to be a more frequent pollution hazard than medium or large feedlots. This may occur because medium and larger feedlots tend to be fewer in number, are newer, are better designed, and use improved methods for manure storage, handling, and application than smaller feedlots.

7. **What are the current and potentially available best management practices and mitigation technologies to prevent against ground and surface water pollution from manure storage, handling, and application, and to what extent are they effective?**

Several management practices and mitigation technologies were reviewed for this scoping question. These included manure storage, handling, and application practices.

Recommended manure storage practices include providing adequate storage capacity, proper engineering design and siting of storage facilities, diverting and collecting runoff water away from surface water bodies, repairing leaks and cracks promptly, and stockpiling manure on impermeable surfaces. Recommended manure collection practices for solid manure include low stocking densities on pastures away from surface water bodies, and impermeable surfaces away from surface waterbodies with proper diversion and collection of runoff on open lots. For liquid systems, the deep pit offers good environmental protection. One of the current limitations in proper application of manure is the lack of reliable calibration of application equipment. Three

types of application methods are common, namely; liquid tank applicators, liquid tow hose irrigation, and box spreaders. Liquid tank applicators have the least environmental impact if manure is injected during application. Tow hose irrigation can lead to excess ammonia volatilization, or runoff of liquid manure if applied in excess to sloping land. Box spreaders are notoriously difficult to calibrate, and are rarely used with incorporation of manure.

Animal manure has been land-applied for centuries to supply nutrients for improving crop growth and yield. Within the last generation, however, concern that animal manure may be degrading water resources has increased. Reasons for this have been due largely to poor manure application practices, disposal of manure at high application rates, and greater concentrations of animals associated with modern livestock production systems.

Numerous management practices affect the availability of nutrients from land-applied manure, and hence, the potential for nutrient contamination of surface and ground waters. These practices include: (1) rate of application, (2) time of application, (3) incorporation method, (4) nitrification inhibitors, (5) tillage, (6) vegetative filter strips and setback distances, (7) cropping systems, and (8) wetland treatment. Each of these practices is thoroughly reviewed in the report.

Application rate is the single, most important manure management practice affecting the potential for contamination of water resources by nitrogen from manure. Simply said, applying nutrients in excess of crop need, whether from fertilizer or manure, increases the potential for nutrient (N and P) movement to ground and surface water. For phosphorus, while rate of application is important, other factors that influence the potential for contamination of water resources include application method (incorporation is best), and potential for runoff and erosion losses (which can be effectively controlled using conservation tillage). Estimating the proper manure rate is more difficult because: (a) nutrient content among manures varies substantially, (b) application equipment is often not sufficiently precise, and (c) climate and soil properties influence the availability of nutrients from manure.

Application of manure for disposal purposes to soybeans, alfalfa, and grass has been extensively studied in Minnesota. Manure can be applied following corn harvest for soybean at rates totaling about 200 lb available N/acre without incurring environmental risk. Hog manure can be applied prior to planting alfalfa at rates up to 12000 gal/acre with much less environmental risk than applications to established alfalfa. Liquid dairy manure can be broadcast-applied at very high rates to established stands of reed canarygrass without much environmental risk.

Vegetative filter strips are potentially very useful in removing contaminants from runoff on manured lands. Their ability to remove pollutants from manured soils depends upon the type of pollutant, the slope of the field, the amount of runoff and erosion, the presence or absence of concentrated flow (rills), and the length of the filter strip. For slopes less than 9%, with dispersed sheet flow runoff (no concentrated flow), filter strips of from 15 to 20 ft in length are usually able to remove a majority of the sediment, total phosphorus, soluble phosphorus, organic and ammonium nitrogen, and chemical oxygen demand in the incoming runoff from manured plots. Filter strips are not generally able to effectively reduce concentrations of fecal bacteria in

runoff from manured plots.

Also of interest is the use of constructed wetlands to treat animal waste from storage lagoons and basins. Wetlands receiving animal waste are generally very effective at reducing the incoming pollutants. They are typically more effective at removing oxygen demanding substances, ammonium, and organic forms of nitrogen than at removing phosphorus.

8. **To what extent does Minnesota animal agriculture contribute to the hypoxia problem in the Gulf of Mexico?**

Hypoxia is a zone of low oxygen levels (< 2 mg/L) covering an area as large as 7,000 square miles in the Gulf of Mexico in 1997. Unlike freshwater systems where phosphorus is usually the limiting nutrient for growth of algae, in the saline waters of the Gulf nitrogen is the often the most limiting nutrient for growth of diatoms. Agricultural nitrogen sources, and to a much lesser extent phosphorus, have been indirectly identified as a major cause of hypoxia. The primary pathway for nitrogen sources to enter surface waters is after intense rainstorms via subsurface tile drainage systems on poorly drained soils with high organic matter contents receiving excessive rates of nitrogen from fertilizer and/or manure.

The largest source of nitrogen to the Gulf of Mexico from Minnesota is the Minnesota River basin, which generates roughly 5% of the total nitrogen flux to the Gulf of Mexico (see table below). The Mississippi River upstream of the Twin Cities generates roughly 1% of the nitrogen flux to the Gulf. Wastewater treatment plants in the Twin Cities and upstream of the Twin Cities generate around 1% of the total nitrogen flux to the Gulf. Streams in southeastern Minnesota draining to the Upper Mississippi River probably generate about 1% of the nitrogen flux to the Gulf of Mexico. Our best estimate using limited information is that animal agriculture in Minnesota contributes less than 1% of the nitrogen entering the Gulf of Mexico. Minnesota also contributes roughly 4% of the total phosphorus flux to the Gulf of Mexico (see table below). Wastewater treatment plants are responsible for at least half of this contribution. In comparison, nonpoint sources from the Minnesota and Upper Mississippi River basins are together a smaller

Table A: Total Nitrogen and Phosphorus Loads from Various Rivers in the Mississippi River Upstream of Joslin, Illinois, and for Wastewater Treatment Plants (WWTP) in the Twin Cities Metropolitan Area and Upstream of the Twin Cities.

Source	Total Nitrogen Flux	Total Phosphorus Flux
	----------U.S. tons/yr----------	
Discharge to the Gulf of Mexico	1.8 million	152,320
Mississippi River at Joslin, Illinois	165,154	8,800
Minnesota River at Jordan, Minnesota	59,180	1,488
Mississippi River at Anoka, Minnesota	21,059	1,088
St. Croix River at Prescott, Wisconsin	6,132	241
Chippewa River at Durand, Wisconsin	10,318	811
Wisconsin River at Muscoda, Wisconsin	13,376	727
WWTP in Twin Cities and Upstream	12,273	3,212

source of total phosphorus than wastewater treatment plants.

9. **What is the impact of animal agriculture on water quantity and availability (sustainability of water supply)? How does the use of water by animal agriculture compare with that of other industries in Minnesota?**

Livestock water use in Minnesota includes water for consumption, and associated on-farm non-consumption use for the production of milk, meat, eggs and wool. Most of the non-consumption water use on livestock farms is for cleaning of equipment and facilities, with dairy and swine farms being the largest users in this category. The total amount of water consumed by livestock each day in Minnesota is estimated to be about 55 million gallons. The total daily water use on livestock farms (including consumption) is roughly 166 million gallons per day.

In comparison to water used by animals, the total water used in Minnesota for power generation, public usage, industrial processing, irrigation and other uses per day is roughly 3.25 billion gallons in 1994. The 166 million gallons of water used in livestock enterprises represents only 5% of the state water usage each day.

Confined animal feedlot operations require placement of concentrated numbers of animals in unpaved or partially paved areas. Virtually all studies affirm that concentrated animal populations and animal traffic cause increased soil compaction. In feedlots, a dense soil layer typically exists near the soil surface that decreases water intake. This dense soil layer impedes infiltration, causing greater runoff volumes and peak flows. From 50 to 85% of the annual rainfall can runoff from feedlots that have from one-quarter to three-quarters of their area covered with concrete, but much of this runoff can be controlled with detention basins and diversions.

10. **How does animal manure compare to other types of wastes produced in Minnesota as a source of water pollution?**

The primary sources of nutrients that cause water pollution in Minnesota include animal waste, human waste, migratory wildfowl wastes, fertilizers, and recycled nutrients from the soil. Estimating the relative magnitude of the impacts from each source is a difficult task involving several assumptions. The results of this exercise are summarized in the following table:

Table B: Minnesota Estimates of Nutrient Production From Various Sources

Source	Total Nitrogen	Total Phosphorus
	----------U.S. tons/yr----------	
Excreted Animal Manure	244,566	65,862
Excreted Human Waste	14,503	6,855
Migratory Wildfowl	2,987	1,613
Fertilizer Sales	729,702	130,866
Soil Organic Matter	946,577	- - - -
Various Nitrogen Credits	288,322	- - - -
Atmospheric Deposition	134,000	- - - -
Crop Removal by Harvest	879,500	197,700

It is important to avoid direct comparisons of some of these numbers. The nitrogen and phosphorus from human waste and migratory wildfowl are discharged directly into streams and rivers, while only a small fraction of the animal waste eventually reaches surface waters. Much of the nitrogen from animal waste is volatilized to the atmosphere during storage, handling, and application of the manure. Only a portion of the nutrients in animal which is eventually applied to land enters streams and rivers through runoff, erosion, and tile drainage.

It is possible to make some rough comparisons between the nutrient contents of animal wastes, fertilizers, and crop removal. Amounts removed by harvest are estimated at 879,500 tons of nitrogen per year and 197,700 tons of phosphorus per year. The amount of phosphorus removed at harvest is nearly equal to the combined amounts of phosphorus from fertilizer and animal manure, suggesting that very little excess phosphorus is available for losses to the environment.

An evaluation of the total nitrogen budget is much more difficult than that for phosphorus. At this time we do not have values for some of the major sinks of nitrogen. Using what is known, the amount of nitrogen removed at harvest is roughly 10% less than the amount potentially available in fertilizer and excreted manure. Since significant losses of nitrogen from manure can occur by volatilization during storage, handling, and application, the amounts of nitrogen removed at harvest are probably quite close to the total amount of nitrogen available for crop uptake from fertilizers and manures. When other nitrogen sources such as soil organic matter, various nitrogen sources and atmospheric deposition are considered, there is a clear state-wide excess of nitrogen applied as fertilizer and manure. We do not know if the unaccounted for nitrogen sinks would balance the excess at this time. If they do not, then the state-wide excess is a potential risk for degradation of surface and ground water quality.

Introduction

The Generic Environmental Impact Statement (GEIS) on Animal Agriculture was authorized and funded in 1988 by the Minnesota State Legislature and ordered by the Environmental Quality Board. The GEIS is composed of three phases, of which this report is the first phase. The first phase is a literature review, the second is research on knowledge gaps identified through the literature review, and the third is preparation of the actual GEIS which involves evaluation of existing and alternative practices and the formulation of policy options for animal agriculture.

The EQB has requested assistance in studying twelve topic areas broadly classified as addressing Social, Economic, Environmental, or Health concerns associated with animal agriculture. This report addresses the environmental concerns associated with Water Resources, including questions dealing with water quality and water quantity. The ten specific scoping questions which we were requested to answer, along with the primary writers for each answer, include:

1. To what extent are groundwater and surface water affected by or at risk from animal manure storage, handling, and application? Primary writer D. J. Mulla.
2. How do the effects or risks (from #1) affect the use of water by humans for drinking, recreation, and other purposes? Primary writer D. J. Mulla
3. How do the effects or risks (from #1) affect fish and wildlife (such as fish kills due to pollution)? Primary writer J. Perry
4. What are the health risks to humans from contamination of ground and surface waters from animal manure storage, handling, and application? Primary writers S. Goyal, B. Wheeler, and C. Alexander
5. To what extent are surface waters affected by or at risk from allowing pastured animals (primarily cattle) access to surface waters? Primary writer B. Vondracek
6. How do the various impacts in #1 to #5 vary by species, operation, system type, management, geography, geology, watershed characteristics, and concentration of livestock facilities? Primary writer D. J. Mulla
7. What are the current and potentially available best management practices and mitigation technologies to prevent against ground and surface water pollution from manure storage, handling, and application, and to what extent are they effective? Primary writers G. Randall and D. J. Mulla
8. To what extent does Minnesota animal agriculture contribute to the hypoxia problem in the Gulf of Mexico? Primary writer D. J. Mulla
9. What is the impact of animal agriculture on water quantity and availability (sustainability of water supply)? How does the use of water by animal agriculture compare with that of other industries in Minnesota? Primary writers J. Linn and G. Sands
10. How does animal manure compare to other types of wastes produced in Minnesota as a source of water pollution? Primary writer D. J. Mulla

Critique of Scoping Questions

Answering the scoping questions from a review of the literature proved to be challenging. While many useful references were found that were pertinent to the scoping questions, individual studies tended to be limited to a single type of animal operation, a specific set of site characteristics, and a particular geographic location. The primary difficulties encountered included:

- Scoping questions were often worded in very general fashion, leaving the possibility of interpretations that vary depending upon stakeholder perspectives. This is particularly true of scoping questions #1, 3, 5, and 6. For these questions, it would be particularly useful to identify the specific combinations of factors whose impact is desired.

- Separating the impacts of animal agriculture from the impacts from fertilizers, human waste, and wildfowl waste was not easy, whether dealing with water contaminant concentrations or loads, with pathogens, or with fish kills. In both surface and ground water, degradation in water quality is often the result of multiple effects which cannot easily be separated. This issue is particularly relevant to scoping questions #1, 2, 6, 8, and 10.

- Comparing the relative impacts of a wide variety of animal operation characteristics and animal species across different soil, climatic, and geologic characteristics as requested in scoping question #6 was often not possible based on the reviewed literature. The individual impacts under specific conditions could be obtained, but comparisons of a wide range of species and operations for a similar set of site characteristics are not commonly reported in the literature.

- In a few cases, results from one study contradicted the results in another study. Our conclusions are based upon the preponderance of results from all studies reviewed.

In some cases the original scoping questions did not request information that our group deemed to be pertinent to the GEIS. Some of these gaps include:

- What are the geographic relationships between existing patterns in water quality degradation and animal agriculture?

- What are the various alternatives to existing animal agricultural practices, and what is the impact of these alternatives on water quality?

- How does age of animal operation facilities influence their potential for pollution of water?

- What relationships and trade-offs exist between air quality and water quality degradation from manure holding basins?

- How long does it take to restore water quality in watersheds that have been impaired by animal agriculture?

- What are the impacts of animal trampling on runoff and infiltration in feedlots and grazed areas? How do runoff and erosion from various types of animal operations differ as a function of type of operation and site-specific characteristics such as climate, slope, and soil type?

In some cases, we have addressed these issues in our report. In other cases we have not, and it would be fruitful for additional effort to be spent in obtaining information to answer the question during the second phase of the GEIS.

1. To what extent are ground water and surface water affected by or at risk from animal manure storage, handling, and application?

General Overview of Water Quality Issues

Surface and ground water are precious resources to be protected from various types of pollution arising from animal agriculture. Surface waters can be degraded by excess nutrients (nitrogen and phosphorus), pathogens, and oxygen demanding organic materials whose effect is measured using chemical or biochemical oxygen demand (COD or BOD). Nutrients and oxygen demanding organic materials in excessive quantities can lead to diminished oxygen levels in water, as measured by dissolved oxygen. Ground waters can be degraded by excess nutrients and pathogens. Degradation can also occur with less well studied substances such as heavy metals and hormones.

Degradation of water quality can take many forms. Excessive quantities of pathogens (bacteria, viruses, and protozoa) can cause disease in humans, especially the very young or old, or the ill. Diseases carried by bacteria include salmonellosis, diseases carried by viruses include hepatitis, and diseases carried by protozoa include cryptosporidia (CAST, 1996). Phosphorus in excess quantities stimulates the growth of algae, leading to potential eutrophication of waters as algae die, decompose, and reduce oxygen levels in the water. Eutrophication can cause the death of fish and other aquatic organisms, as well as other physical and chemical changes in the water quality of a lake, stream, or river. Not all forms of phosphorus contribute equally to growth of algae. The soluble form (orthophosphate-phosphorus) is much more bioavailable than the form bound to soil particles (particulate phosphorus).

Excess nitrogen in surface waters can also lead to eutrophication. Nitrogen (N) occurs in different forms, with the most common being ammonia, ammonium, organic nitrogen, and nitrate. Ammonia in excessive quantities can produce an oxygen demand similar to soluble phosphorus, and can be toxic to fish (CAST, 1996). Ammonium is the ionized form of ammonia, and the conversion between the two forms depends upon temperature and pH. Ammonium is also easily converted to nitrate. Nitrate in excessive quantities can cause

methemoglobemia, which can be fatal to human infants. Organic forms of nitrogen and free ammonia are estimated using the total Kjeldahl nitrogen measurement.

Finally, degradation of water can occur when it contains excess quantities of organic materials which consume oxygen as they decompose. The oxygen consumption potential is measured using biochemical oxygen demand (BOD) or chemical oxygen demand (COD). When surface waters become polluted, their use for drinking water, fishing, boating, swimming, and other tourism uses is reduced.

Numerical water quality standards are commonly expressed as concentrations (mass per volume). The most common units for concentrations are micrograms per liter (ug/L) which is roughly equivalent to parts per billion (ppb), and milligrams per liter (mg/L) or milligrams per kilogram (mg/kg) which are both roughly equivalent to parts per million (ppm). Concentrations of pathogens are commonly expressed as colony forming units (CFU) per hundred millileters (mL), where CFU is the number of colonies formed after growing pathogens on an agar plate.

Table 1: Selected Numerical Water Quality Standards for Common Minnesota Lake and Stream Uses

	Numerical Standard		
Usage Class	Unionized Ammonia	Dissolved Oxygen	Fecal Coliform
	Cug/LC	Bmg/LB	CFU/100 mL
Class 2A	16	5	200
Class 2Bd	40	5	200
Class 2B	40	5	200
Class 2C	40	5	200

Water quality standards (Table 1) are often not a good indicator of the potential for eutrophication of surface waters. Dodds et al. (1996) studied 1,400 rivers and streams throughout North America, Europe, and New Zealand, and found that critical concentration levels for the onset of eutrophication were 1.5 mg/L of total nitrogen and 0.075 mg/L of total phosphorus. EPA guidelines for critical concentrations of total P in streams and lakes are 100 ug/L and 50 ug/L, respectively. Eutrophication is often assessed using chlorophyll a levels, a measure of the phytoplankton biomass present. Chlorophyll a concentrations greater than roughly 35 ug/L are often perceived by the public to be associated with eutrophic conditions that limit swimming and aesthetic uses of lakes (Heiskary and Wilson, 1989).

In an excellent review by Wall and Johnson (1996), several factors affecting impairment of water quality from land application of manure were described. Impacts on surface water quality can also occur from surface runoff from feedlots, and as a result of spills from manure

storage lagoons. Surface water can also be impacted from tile drain effluent on lands receiving manure applications. Impacts on ground water quality can occur by leaching losses from lands receiving applications of manure, as well as from seepage and leakage of manure waste storage lagoons. The information in the review by Wall and Johnson (1996) is complementary to the findings of this study in that they summarize much of the older literature, and a copy of their review is being provided to members of the EQB and CAC. The following two sections review more recently published literature dealing with the impacts of animal agriculture on surface and ground water quality.

Effects of Animal Agriculture on Water Quality from Surface Runoff

Runoff can carry organic forms of nitrogen, particulate and soluble phosphorus, pathogens, and oxygen demanding organic matter into rivers and streams. This section reviews the magnitudes of pollutant losses in runoff from various land uses and animal manure management practices at the watershed and plot scales.

Comparison of Causes of Impaired Rivers and Streams for Various Land Uses

Water quality of rivers and streams can be degraded by runoff from a variety of land uses, including urban runoff, and runoff from agricultural cropland receiving fertilizer, cropland receiving manure and fertilizer, feedlots, animal grazing pastures, rotational grazing pastures,

Table 2. Percent of Load Contributed in Impaired Watersheds by Various Factors (Smith et al. (1997):

Source	Total Phosphorus	Total Nitrogen
	% of Load	
Point Sources	7.9	10.6
Fertilizer application	21.0	47.9
Livestock waste application	37.7	15.4
Non-agricultural land	33.4	18.0
Atmospheric deposition	0	8.2

forests, or natural prairies. The relative magnitude of this impact on watersheds is dependent upon site-specific characteristics such as climate, landscape, soils, and intensity or management of land use. In this section we review references that deal with the impacts from various land uses on water quality.

Smith et al. (1997) used the Spatially Referenced Regression on Watershed (SPARROW) attributes method to study the factors affecting total nitrogen and total phosphorus loads in 414 surface streams and rivers in the U.S. (Table 2). They found that roughly half of the total

nitrogen (TN) in impaired watersheds was caused by fertilizer applications. Livestock waste was a less significant source, contributing 15% of the total nitrogen load in seriously impaired watersheds. This TN load represented 24% of the nitrogen generated by manure. Roughly one-third of the total phosphorus (TP) load in impaired watersheds was attributable to livestock waste, and this TP load represented 7.2% of the phosphorus generated by manure. Non-agricultural land generated another one-third of the TP load, while fertilizer applications generated one-fifth of the TP load. From this study, we can conclude that impairment of watersheds is caused by a variety of sources. For phosphorus, the major sources are livestock waste and non-agricultural land, with fertilizers being less important. For nitrogen, the major source is fertilizer, with smaller contributions from non-agricultural land, livestock waste, and point sources. Some of the nitrogen in atmospheric deposition may also originate from animal agriculture, due to volatilization of ammonia from animal manure and subsequent redeposition.

In the central U.S., a General Accounting Office report to the U.S. Senate (GAO, 1995) concluded that in the midwestern U.S. manure is the source for 37% of the nitrogen and 65% of the phosphorus loading to watersheds. These figures are greater than those obtained by Smith et al. (1997) for the entire U.S., indicating the greater impact of animal manures on surface water quality in the midwest than the nation as a whole.

Rather than evaluating the percent load contributed by animal manures, Ritter (1988) and Sweeten (1998) compared and contrasted the annual losses of total nitrogen and total phosphorus from various land uses (Table 3). They found that direct runoff from feedlots contained excessively high amounts of nitrogen and phosphorus, while losses in runoff from nonpoint agricultural land uses exhibited a wide range of impacts depending upon the specific type of management and site conditions. In general, losses from urban land uses (per unit area) were comparable in magnitude to losses from agricultural nonpoint sources, while losses from forested systems were less. Nutrient losses from cropland, fields receiving manure applications, and grazed pastures were all of comparable magnitude. The lowest losses in runoff occurred with rotational grazing and native prairie, and with well managed cropland or grazed pastures. These results do not account for the differences in total acreage of each land use (the total impact would be obtained by multiplying acreage by rates of loss). After doing so, the total losses from agricultural nonpoint land uses would be much greater than the total losses from urban areas or feedlots due to the differences in total acreage.

Table 3: Typical Runoff Losses of Nitrogen and Phosphorus from Various Land Uses.

Land Use	Runoff Losses	
	Total Nitrogen	Total Phosphorus
	lb/ac	
Grazed pastures	0.5-8.7	0.36-4.1
Rotational grazing	1.3	0.8
Native prairie*	0.9	0.1
Forest	2.7-11.6	0.03-0.9
Land applied dairy manure*	2.5-3.3	0.4-0.5
Cropland	0.09-11.6	0.05-2.6
Urban	6.3-8.0	0.98-5.0
Uncontrolled Feedlot	89-1,428	8.9-553

*Minnesota data

Shuyler (1992) estimates that nonpoint sources generate 82% of the nitrogen and 68% of the phosphorus loading to Chesapeake Bay. Wastewater treatment plants are the primary point source contributor for the remaining 18% of the nitrogen and 32% of the phosphorus. Animal waste in the Chesapeake Bay represents 0.04% of the basin land uses, but generates 22% of the nitrogen loads and 7% of the phosphorus loads in the basin. Five of the ten major watersheds in the Chesapeake Bay Basin generate 93% of the nitrogen loads from animal wastes and 94% of the phosphorus loads. Because most of the animal operations in the Chesapeake Bay have less than 1000 animal units, they were not required to have discharge permits. Because of this, Shuyler (1992) states that much of the nonpoint source pollution from animal wastes in the Chesapeake Bay originates in runoff from unpermitted animal production facilities, rather than runoff from lands where manure is applied.

Three adjacent watersheds in Maryland with primarily cropland, animal pasture grazing, and forest land use were monitored for over 14 years (Correll et al., 1995). No fertilizer was applied in the pasture watershed, and no manure was land applied in the cropland watershed. The results of this monitoring (Table 4) indicate that cropland was the greatest contributor to water quality degradation in the watersheds studied, with the exception of organic phosphorus. Animal grazing on pastures had much lower impacts on water quality than cropland production.

Table 4: Nutrient Losses from Various Land Uses in Maryland.

Water Quality Parameter	Watershed Discharge Loss (lb/ac)			
	Cropland	Pasture	Forest	Highest Loss
Total Organic Nitrogen	2.8	07	1.4	Cropland
Nitrate-Nitrogen	3.4	0.5	0.1	Cropland
Total Ammonium-Nitrogen	0.4	0.2	0.2	Cropland
Total Nitrogen	6.7	1.4	1.7	Cropland
Total Organic Phosphorus	1.1	0.2	1.6	Forest
Total Phosphate Phosphorus	1.2	0.2	0.2	Cropland
Total Phosphorus	2.4	0.3	0.3	Cropland

Sharpley et al. (1998b) studied a 40 ha catchment in eastern Pennsylvania with distinct differences in land use. Plant available phosphorus concentrations in surface soil were <30 mg/kg in woodlands, between 100-200 mg/kg in grazed pastures, and >200 mg/kg in cropped fields receiving manure and fertilizer. Phosphorus loss to streams was greatest in near stream areas with high levels of plant available phosphorus in the soil. These near-stream areas should be targeted for P source reduction and management of runoff and erosion because they generate the majority of phosphorus entering streams.

Patni et al. (1985) compared the levels of bacteria in streams draining manured cropland, unmanured cropland, and uncultivated land in Canada. Liquid dairy manure was applied to flat poorly drained lands during dry weather, not to frozen ground, and was plowed under after application. No significant differences in the fecal coliform or fecal streptococci levels of manured and unmanured watersheds were observed. Elevated fecal coliform levels in unmanured soils were from geese, ducks, seagulls, groundhogs, and muskrats. Storing manure for from 6-30 weeks in outside covered concrete storage tanks before application reduced fecal bacteria counts in manure by 3 orders of magnitude, making pathogen levels in manured lands comparable to those in unmanured lands.

Wiggins (1996) developed an accurate method for identifying fecal streptococci from waste matter of turkeys, chickens, dairy cattle, beef cattle, humans, and wildlife in the presence of five antibiotics. Discriminant analysis of the antibiotic resistance patterns from each source was used to classify the source of fecal streptococci in water samples from two streams draining agricultural areas in Virginia. The source of fecal streptococci in Cooks Creek was 59% beef cattle, 18% dairy cattle, 11% human, 11% wildlife, 1% chickens, and 0% turkeys. In Muddy Creek the sources were 68% beef cattle, 15% wildlife, 8% chicken, 6% dairy cattle, 2% turkeys, and 1% human. Thus, in these two watersheds, over 80% of the fecal streptococci were from domestic livestock. The much greater contribution from livestock sources in this study compared to the study above by Patni et al. (1985) could be due to land application of fresh manure or uncontrolled runoff from feedlots in the Virginia study.

The results of the study by Wiggins (1996) may not be readily extrapolated to other regions. This is particularly true in unsewered rural areas of Minnesota where high water tables and poorly drained soils are present. In these areas, individual sewage treatment systems (septic tanks and drainfields) may not be installed, resulting in the direct discharge of large quantities of pathogens from human waste into ditches, creeks, and streams without significant treatment. The Minnesota Pollution Control Agency (MPCA, 1994a) has estimated that in the Minnesota River basin 45% of the 68,000 septic tanks discharge directly (and illegally) to surface waters without treatment.

The main points observed from references in this section include:

- Livestock waste can contribute significantly to phosphorus loads in surface waters (7-65% of total load), although another major source is non-agricultural land. Livestock waste usually contributes less significantly to nitrogen loads (15-37% of total load). However, the primary source of watershed impairment from nitrogen is fertilizers.

- Nutrient losses per unit area in runoff can be greater in magnitude from croplands, manured croplands, and grazed pastures than from rotationally grazed lands, forest lands, or natural prairies. Losses from well managed cropland or grazed pastures can be comparable to the small losses observed on rotationally grazed lands.

- Critical areas for phosphorus loss to streams and lakes are typically those areas high in soil

available phosphorus in close proximity to waterbodies.

- Feedlot runoff contains extremely large loads of nutrients and oxygen demanding substances, and if not properly collected and prevented from entering surface waters, this runoff can severely degrade surface water quality.

- Fecal bacteria in surface waters from manured lands is often not significantly different from pathogen levels in surface waters from unmanured lands if the manure has been stored and aged before land application. Natural wildlife can be a significant source of fecal bacteria leading to surface water quality degradation.

- Fecal bacteria in surface waters from lands receiving fresh manure applications can be a significant proportion (over 80%) of the fecal bacteria carried in surface waters. Where illegal discharge of septic tanks to surface waters occurs, human waste can also be a significant source of pathogens in surface waters.

Plot Scale Studies on Nutrient and Pathogen Losses from Agricultural Activities

Runoff Losses

Nutrient Losses in Runoff

Sharpley et al. (1998a) stated that losses of nitrogen and phosphorus in runoff are affected by rate, method and timing of manure application, tillage, rainfall intensity and timing, and slope steepness. Other important factors for phosphorus losses include erosion rate, soil phosphorus levels, soil phosphorus sorption saturation levels, and proximity to waterbodies (Wall and Johnson, 1996). Finally, the crop to which manure is applied influences the amount lost in runoff.

One of the most commonly asked questions is whether there is any difference in runoff losses of nutrients from manured versus fertilized cropland. To answer this question, Gangbazo et al. (1995) applied fertilizer and hog manure to a Coaticook silty loam cropped to corn in fall, spring, or split between fall and spring. Plots with fertilizer plus hog manure had significantly higher ammonium-N losses in runoff than plots receiving only fertilizer. Losses of ammonium-N from the control (160 lb N/ac fertilizer) were 1.1 lb/ac/yr, losses from the spring applied fertilizer (160 lb N/ac) and manure (321 lb N/ac) were 1.1 lb/ac/yr, losses from the spring applied fertilizer (160 lb N/ac) and fall applied manure (321 lb N/ac) were 2.8 lb/ac/yr, and losses from the split application of 160 lb N/ac fertilizer in spring, 160 lb N/ac manure in fall and 160 lb N/ac manure in spring were 1.6 lb/ac/yr. Thus, when applied at equivalent rates of nitrogen, runoff losses of nutrients were equivalent for fertilizer and manure applications. Also, the worst management practice was fall application, followed by split application. Spring application of manure had runoff losses comparable to the spring application of fertilizer.

In an extension of their studies from 1995, Gangbazo et al. (1997) applied 136 lb N/ac as

fertilizer or hog manure to fall chisel plowed plots with a silty clay loam texture and a 7% slope. There were no significant differences in loads of nitrogen or phosphorus lost in runoff for fertilized versus manured plots receiving equivalent rates of nutrient input. During snowmelt runoff, 90% of the water loss was in runoff, while in early spring after snowmelt runoff, 92% of the water loss was in tile drainage. Total spring loads were 40 to 70% of the total annual nutrient loads lost in runoff and drainage.

Another common question relates to the effect that manure application rate has on runoff losses. Daniel et al. (1995) studied the effect of poultry litter and swine manure application rate on runoff losses from a Captina silt loam with a slope of 5%. They found the following results (Table 5):

Table 5: Runoff losses (lb/ac) as a function of manure application rate and source of manure for a rainfall intensity of 2 inch/hr:

	Treatment				
Water Quality Parameter	Control	Poultry	Swine	PoultrySwine	
		-----194 lb N/ac------		-----388 lb N/ac------	
	lb/ac				
Ammonia-N	0.0	3.3	3.8	5.8	7.5
Nitrate-N	0.0	0.0	0.0	0.0	0.0
Total Kjeldahl-N	0.2	8.0	5.2	18.2	11.2
Total Phosphorus	0.0	1.1	1.3	2.4	4.3
Orthophosphate	0.0	1.1	1.3	2.1	4.3
Chemical Oxygen Demand	2.4	39.4	31.8	46.3	71.5

These results show that application of manure at excessive N rates (388 lb N/ac) significantly degraded water quality of runoff (ammonia, phosphorus, COD) compared to the control which received no manure. No nitrate was observed in runoff at any rate of application because nitrate is soluble and leaches through the soil without entering runoff. They also show that losses of pollutants increase with rate of manure applied. Finally, they show that swine manure runoff tends to be more polluting for ammonia, total phosphorus, and COD than poultry litter if applied at excessive rates, probably because mixing bedding with poultry manure to make litter reduced the availability of pollutants for runoff.

Runoff losses can be significantly influenced by method of application. Ross et al. (1979) found that injection of liquid dairy manure in a Maury silt loam soil greatly reduced the concentrations of COD, nitrogen, and dissolved oxygen in runoff compared to surface applications. Rates of runoff were also reduced on plots with injected manure.

A few large storms generally produce the majority of the runoff and erosion from

agricultural fields (Larson et al., 1997). Delaying the time between application of manure and rainfall by 1 day reduced concentrations by at least 80% (Ross et al., 1979). Daniel et al. (1995) also found that runoff losses were worst for the first storm following application of manure, and that runoff losses doubled as rainfall intensity doubled.

Wall and Johnson (1996) conducted an extensive review of the impacts of various cropping systems on runoff losses of phosphorus. They concluded that runoff losses of total phosphorus were generally much smaller for natural woodland, natural prairie, and forested land than for cropland receiving manure applications. Losses of total phosphorus from manured alfalfa were generally less than losses from manured corn.

Long (1979) showed that dairy manure applications of 20 tons/ac to bermudagrass on a sandy loam caused slight increases in BOD, ammonium-N, and nitrate-N levels in runoff compared to plots receiving no manure. No serious long-term effects on runoff water quality would occur from these applications.

We can conclude from these references on surface runoff losses of nutrients that:

- The most significant components of losses in surface runoff are for ammonium, total and orthophosphate phosphorus, and oxygen demanding organic materials. Nitrate-nitrogen is rarely a significant component of surface runoff.
- Nutrient losses in runoff from manured or fertilized fields were much greater than losses from unmanured or unfertilized control plots.
- Nutrient losses in runoff increased with the rate of manure or fertilizer applied.
- Losses of nitrogen and phosphorus in runoff from manured and fertilized fields were not significantly different if the manure and fertilizer were applied at equivalent rates of nitrogen content.
- Nutrient losses in runoff from manured fields decrease when manure is injected or if manure is stored for several weeks before land application.
- Nitrogen losses in runoff from manured fields are least when manure is applied in spring (especially late spring), and greatest when manure is applied in fall.
- Nutrient losses in runoff from manured fields increase when the time between land application and rainfall is brief, especially for intense rainfall events.
- Nutrient losses in runoff from manured fields are usually excessive when land application to snow or frozen soils occurs.
- Losses of phosphorus in runoff are generally greater when manure is applied to corn rather

than alfalfa or grass, but can be negligible when erosion and runoff are controlled on corn fields using conservation tillage. In comparison, phosphorus losses in runoff from manured corn are generally greater than losses from natural prairie, woodlands, and forest lands.

Pathogen Losses in Runoff

Surface water quality is deemed to be impaired if an indicator of pathogens, fecal coliform, is present in counts greater than 200 Colony Forming Units (CFU) per 100 mL of water. Fecal coliform is not typically a health risk to humans, but it is potentially an indicator of other pathogens that can pose a health risk, such as salmonella.

Culley and Phillips (1982) studied fecal bacteria in surface from 0.2 acre sandy clay loam plots receiving liquid dairy manure, fertilizer or no fertilizer for six years. Liquid manure was applied at three rates, and was either plowed under after harvest, plowed under in spring prior to seeding, or plowed under with split applications in spring and fall. In one treatment, manure was applied to snow or frozen ground. Fecal bacteria levels in runoff from manure applied in fall or spring at any rate were not significantly different from fecal bacteria counts in fertilized or unfertilized plots, and were from one to two orders of magnitude greater than the primary contact level of 200 CFU/100 mL. Application of manure to snow or frozen ground resulted in significantly greater counts of fecal bacteria in runoff than any other treatment.

Cooke et al. (1997) studied fecal coliform and fecal streptococci in surface runoff in relation to fall, late winter, and spring applications of manure at rates of 150 and 300 lb/ac N by either injection or broadcast. An inorganic fertilizer control receiving 150 lb N/ac was also included. Fecal bacteria levels in surface runoff were consistently high for all treatments (commonly between 5,000 and 50,000 CFU/100 mL), including the unmanured treatment.

Edwards et al. (1997) studied fecal bacteria in runoff from grazed versus ungrazed and manured versus unmanured fields ranging from 1.5 to 3.7 acres in size for three years. Fecal coliform in runoff exceeded 200 CFU/100 mL 89% of the time for all runoff events, and there were no significant differences in fecal coliform levels in runoff for grazed versus ungrazed or manured versus unmanured plots. This lack of difference could be due to die-off of fecal bacteria during the time between application and runoff. The ratio of fecal coliform to fecal streptococci was not a reliable indicator of the source of fecal bacteria in runoff.

From this section we can conclude:

- There were no significant differences in fecal bacteria levels in surface runoff (all levels were greater than primary contact limits) from manured versus unmanured or grazed versus ungrazed lands. This is due to fecal bacteria from natural wildlife, and die-off of bacteria in manure after storage or land application.

- Rate, method, or timing (spring versus fall) of manure application has little effect on fecal bacteria counts in surface runoff.

- Fecal bacteria counts in surface runoff are significantly greater after application of manure to snow or frozen soil than after application at any other time of year.

Hormone Losses in Runoff

There has recently been much concern over the presence of estrogen and estrogen-like compounds in surface waters. These hormones, when present in high concentration, are linked to reduced fertility, mutations, and death of fish. Shore et al. (1995) summarized the estrogen and testosterone concentrations from various sources (Table 6), including chicken litter:

Table 6: Hormone Concentrations found in Various Sources.

Source	Estrogen	Testosterone
	----------ng/L----------	
Raw sewage effluent	40-200	16-700
Septic tank effluent	40-130	----
Aqueous extract of sludge	18-70	10-173
	----------ng/g dry wt----------	
Chicken litter	14-533	133-670

Little is known on losses of hormones from land application of manure, and no studies have been conducted on the impact to human health of hormones in drinking water from manured watersheds. Four streams in the Conestoga River watershed had testosterone levels ranging from 1.2 to 4.1 ng/L and estrogen levels ranging from 0.8 to 2.9 ng/L (Shore et al., 1995). Three of the sampled sites were affected by fields receiving poultry litter, and one was affected by a sewage treatment plant. Runoff from a field receiving poultry litter had from 5-23 ng/mL estrogen. Testosterone is thought to be more susceptible to leaching losses than estrogen, while estrogen is more likely to be lost by runoff than leaching.

Nichols et al. (1998) stated that fish exposed to 0.25 ug/L of estradiol (an estrogen hormone) often have gender changes, while fish exposed to from 10-200 ug/L can die. Concentrations of estradiol in runoff from a field receiving poultry litter were reduced 94% from 3.5 ug/L with no vegetative filter strip to 0.2 ug/L with a 60 ft wide vegetative filter strip. Vegetative filter strips as narrow as 20 ft were found to be very effective at reducing concentrations of estradiol in runoff. In another study, Nichols et al. (1997) found that a 42-46% reduction in runoff concentrations of estradiol from plots receiving poultry litter could be attained by amending the litter with alum.

These studies on hormones in runoff from manured lands are very limited. They show that hormones are present in animal manures, and in surface waters from watersheds where

animal waste is applied. Hormones in runoff from manured lands can be significantly reduced by treatment of runoff with vegetative filter strips. Sources of hormones other than animal waste are also very important in surface waters.

Insecticide Losses in Runoff

There has been almost no research on losses of pesticides in runoff from manured lands. Pote et al. (1994) showed that losses of cyromazine (used to control flies in poultry litter) in runoff increased with the rate of poultry manure applied and the intensity of rainfall. Percent losses of cyromazine were 10 and 13% at low and high rates of manure under low intensity rainfall, and 23 and 24% at low and high rates of manure under high intensity rainfall. The impacts of these losses on surface water quality are of unknown magnitude or extent.

Tile Drainage Losses

Nutrient Losses in Tile Drainage

The major factors which influence losses of nutrients through tile drains include rate of application, timing of application, form and method of application, tillage, and cropping system. The impact of each of these factors will be described below.

Many studies on the effect of manure application rate on tile drain losses of nitrate have been conducted. Kanwar et al. (1995) showed that nitrate concentration and yields in tile drains located in Iowa increased with the rate of nitrogen applied. In another Iowa study, Cook and Baker (1998) applied swine lagoon effluent to no-till soil at rates of 1.1 (1X rate) and 3.3 (3X rate) inches. Tile lines were monitored for nutrient levels. A control with no added manure was also included. Tile drainage for the 1X manure treatment and the control were very similar in nitrate loads (<4.5 lb/ac), total Kjeldahl N (<0.05 lb/ac), and total phosphorus (<0.02 lb/ac). The high rate (3X) manure treatment had significantly higher levels of water pollutants, with nitrate levels of 8.9 lb/ac, total Kjeldahl loads of 2.7 lb/ac, and total phosphorus loads of 0.5 lb/ac. Thus, increasing the rate of applied manure to excessive rates causes greater losses of nutrients through tile drains.

Baker et al. (1975) showed that phosphorus can leach to tile drains if manure is applied at excessive rates. Hergert et al. (1981) monitored soluble P in tile drains before and after applying moderate to high amounts of dairy manure to a poorly drained silt loam. The probability of exceeding 30 ppb soluble P before manuring (5%) or after manuring with the moderate rate (8%) were much lower than after manuring with the high rate (47%). Losses of soluble P were roughly 5-10 times greater in surface runoff than tile drainage from manured plots.

Heckrath et al. (1995) studied P leaching to tile drains from soils differing in long-term management at Rothamsted, U.K. Soils received no P, P in manure at 35.7 lb/ac, or fertilizer at 31.2 lb/ac for 100 years. Losses of P from manured plots were comparable to losses in control plots, and significantly lower than losses in fertilized plots. Soil test P levels (using the Olsen

test) greater than 60 mg/kg were associated with significant increases in P losses through tile drainage.

There have been questions about the relative impact of manure versus fertilizer on losses of nitrogen through tile drain systems. Two important studies have been conducted to answer this question. In Iowa, Hegde and Kanwar (1997) showed that nitrate losses in tile drainage were 15.2 lb/ac from application of Urea Ammonium Nitrate (UAN) fertilizer and 9.5 lb/ac from an equivalent spring application of liquid swine manure. All concentrations of nitrate were below the drinking water Maximum Contaminant Limit (MCL) of 10 mg/L. Nitrate losses from a very high application rate of swine manure were actually decreased (from 9.5 lb/ac) to 7.1 lb/ac due to enhanced denitrification resulting from high organic carbon in applied manure and wet soil conditions. In Minnesota, Randall et al. (1999a submitted) studied nutrient losses in subsurface drainage water from dairy manure and urea applied to corn at two rates. There were no significant differences in tile drain losses of nitrate-N, total P, and orthophosphorus-P concentrations between manured and fertilized plots. Losses of nitrate-N were greater than 10 mg/L at all rates and forms applied, while losses of phosphorus in tile drainage were negligible.

Hardeman et al. (1997) showed that increasing the rate of swine manure application from 150 to 300 lb N/ac increased the nitrate levels in tile drains, independent of whether the manure was applied in fall or injected during spring. Hardeman et al. (1998) found no significant differences in tile drainage losses of nitrogen from applications of fertilizer, fall injected swine manure, winter broadcast swine manure, and spring injected swine manure.

Tillage and cropping system can influence nitrate losses from manured fields through tile drain systems. In Iowa, Kanwar et al. (1998) studied nitrate levels in tile drains from plots in crop rotations of alfalfa-corn, corn-soybean-oat-clover strip cropping, corn-soybeans, or continuous corn. Tillage included no-till or chisel plow, and nitrogen was applied either as swine manure or UAN fertilizer. Highest losses occurred with a chisel plowed continuous corn plot (24.1 lb N/ac/yr) receiving high rates of manure and with a no-tilled corn-soybean plot (21.4 lb N/ac/yr) receiving agronomic rates of N fertilizer. A chisel plowed corn-soybean plot receiving high rates of manure lost 15.2 lb N/ac /yr, while an alfalfa corn rotation lost 8.9 lb N/ac/yr. In another study, Foran et al. (1993) showed that tilling soils prior to application reduced pollution. They also found that solid manure applications did not pollute tile drains, while liquid manure injection did.

From these references on nutrient losses in tile drainage effluent, we conclude that:

- The most significant component of subsurface tile drain effluent losses is nitrate-nitrogen. Soluble and total phosphorus losses are generally negligible in comparison to their losses in surface runoff. Losses of ammonium-nitrogen and oxygen demanding organic materials are generally lost in much smaller quantities through subsurface tile drain effluent than through surface runoff.

- Nutrient losses in subsurface tile drainage increase with rate of manure or fertilizer applied, unless very high rates of manure are applied on wet soil, when denitrification reduces the losses of nitrogen. Nitrate losses in tile drains from manured fields are typically less than or equal to losses from fertilized fields receiving equivalent rates of nitrogen.

- Liquid manure applications cause more risk for nitrate leaching to subsurface tile drains than surface applications of solid manure, especially when liquid manure is injected.

- Manure applications to continuous corn will typically cause greater losses of nitrate-N in subsurface tile drainage than manure applications to other crops, all other factors being equal.

- Losses of phosphorus through subsurface tile drainage systems are typically negligible, unless very high rates of manure are applied, or the soil test phosphorus levels have built up to excessive levels.

- No research on the impact of surface tile inlets on nutrient losses from land application of manure through tile drainage systems has been published in peer reviewed journals.

Losses of Pathogens through Tile Drainage

Cooke et al. (1997) described the four main factors affecting survival of enteric bacteria in soil including physiochemical soil properties, atmospheric conditions, biological interactions, and application methods. Factors affecting transport of bacteria through soil included soil physical properties and soil environmental and chemical factors. Fecal coliform and fecal streptococci in tile drains were studied in relation to fall, late winter, and spring applications of manure at rates of 150 and 300 lb/ac N by either injection or broadcast. An inorganic fertilizer control receiving 150 lb N/ac was also included. Higher pathogen levels were likely in tile drainage when manure was injected rather than broadcast. There was no clear effect of rate of manure application on fecal bacteria counts in tile drains. Fecal bacteria levels in control plots receiving no manure were usually below 10 CFU/100 mL. Fecal bacteria levels in tile drains below manured plots were often between 10 and 200 CFU/100 mL.

Geohring (1994) showed that liquid manure applied during the spring to tile drained land was likely to produce very high levels of E. Coli bacteria and ammonium-N, unless the tile drain outlet is temporarily blocked for a day. He recommended that liquid manure applications should be adjusted for soil texture and available water holding capacity, with fine textured drier soils having the capacity for greater amounts of manure application than coarse textured, wetter soils. Manure application rates were also found to depend upon soil type and residue cover, with greater rates allowed on coarser textured soils with significant crop residue cover than on bare, finer textured soils.

Geohring et al. (1998) showed that fecal coliform from surface applications of dairy manure was rapidly transported to subsurface tile drains in fine sandy loam through macropores if the soil was wet before application or a heavy rainstorm occurred within hours of manure

application. Rapid transport of solutes has also been observed through soil macropores to tile drains (within roughly an hour after the onset of precipitation) under conditions typical of Iowa and Minnesota (Everts et al., 1989).

Hegde and Kanwar (1997) found that fecal coliform and fecal streptococci counts increased with manure application rate for the two months following application. Maximum counts of fecal coliform (50 CFU/100 mL) and fecal streptococci (70 CFU/100 mL) did not always correspond to the largest storm events.

Cook and Baker (1998) applied swine lagoon effluent to no-till soil at rates of 1.1 (1X rate) and 3.3 (3X rate) inches. Tile lines were monitored for fecal bacteria. A control with no added manure was also included. Tile drainage for the 1X manure treatment and the control were very similar in fecal coliform or fecal streptococci (usually 100,000 CFU/100 mL). The high rate (3X) manure treatment had significantly higher levels of water pollutants, with fecal bacteria counts exceeding 1,000,000 CFU/100 mL.

Stoddard et al. (1998) studied survival and leaching of fecal coliform and fecal streptococci in a soil receiving dairy manure with spring or fall application and no-tillage or conservation tillage. Manure significantly increased fecal bacteria in leachate (3,000 to 60,000 CFU/100 mL) compared to unmanured soils. Neither tillage nor timing of manure application affected fecal coliform concentrations in leachate.

Randall et al. (1999a submitted) studied pathogen losses in subsurface drainage water from dairy manure and urea applied to corn at two rates. E. coli was found in 24% of the tile drain water samples from manured plots, but no E. coli were found in tile drain water from fertilized plots.

Somewhat contradictory results were observed for transport of fecal bacteria to tile drains. The main conclusions appear to be:

- Manured soils generally, but not always, produced significantly greater levels of fecal bacteria in tile drain effluent than unmanured soils.

- The effect of manure application rate on fecal bacteria levels in tile drainage was not conclusive. The effect of manure application timing on fecal bacteria levels in tile drainage was also not conclusive.

- Fecal bacteria levels in tile drain effluent increased when manure was injected rather than broadcast.

- Transport rates of fecal bacteria to tile drain effluent from land applied manure could be very quick in medium textured soils with macropores.

Effects of Manure Storage Facility Spills and Feedlot Runoff on Surface Water Quality

Catastrophic spills from large manure storage facilities can occur primarily through overflow following large storms or by intentional releases. A third mechanism, collapse of a sidewall is less frequent, and has never occurred in Minnesota (personal communication, Gregory Johnson of the Minnesota Pollution Control Agency). According to Mancl and Veenhuizen (1993), Pennsylvania has about 30 water quality violations each year from animal lagoon spills. Ohio had about 35 violations during 1989, of which 16 caused fish kills. Indiana has 10 fish kills and 25 water quality violation each year. Hallberg (1996) stated that runoff from manure is the number one cause of fish kills in Iowa. According to a report on animal waste pollution by the U.S. Senate (1997), 40 animal waste spills killed 670,000 fish in Iowa, Minnesota, and Missouri during 1996. In 1995 there were 20 spills in those three states, which killed 55,000 fish.

Ackerman and Taylor (1995) stated that 40% of the nearly 80,000 confined animal farming operations in Illinois do not comply with state regulations on discharges to water. Between 1972 and 1992 there were 133 fish kills from discharges of manure. Three case studies were presented (Table 7) showing the effects of feedlot runoff on stream water quality. These results show that direct entry into surface waters of manure from feedlot runoff, storage basin spills, or frozen soil runoff has a devastating local impact on water quality (primarily low oxygen, and high ammonia, phosphorus, and BOD).

Table 7: Water Quality Impact Upstream and Downstream of Manure Spills and Manure Runoff from Frozen Cropland in Illinois.

Event	Water Quality Impact	
	Upstream	Downstream
1000 Hog Feedlot Spill:	----------mg/L----------	
Dissolved Oxygen	6.8	0.0
Ammonium-N	0.7	56.0
Total Phosphorus	0.3	31.0
500 Cattle Manure Storage Tank Spill:		
Dissolved Oxygen	8.2	0.2
Ammonium-N	0.06	60.0
Swine Manure Applied to Frozen Cropland:		
Ammonia-N	---	11.0
Biochemical Oxygen Demand	---	200.0

According to a U.S. Senate report (1997), 35 million gallons of animal waste spilled in North

Carolina during 1995, killing 10 million fish. Serious spills occurred in North Carolina 30 times from 1995-1996. Mallin et al. (1997) studied the impacts for single cases involving a poultry and a swine waste lagoon spill on water quality of receiving streams in North Carolina (Table 8). The poultry waste lagoon spilled 8.6 million gallons of waste into the Cape Fear River at high flow during a 25 year storm event. The hog waste lagoon released 2 million gallons of waste into a nearby creek at low flow. The lagoons served 75,000 chickens and 6,500 hogs. Dissolved oxygen levels from the poultry spill were as low as 1.0 mg/L 56 miles downstream of the spill, and resulted in 200 fish being killed. Dissolved oxygen levels from the hog lagoon spill reached as low as 0.1 mg/L, and did not recover for two weeks when a significant rainfall occurred. Maximum total Kjeldahl nitrogen levels recorded in the streams from the poultry and hog lagoon spills were 92 mg/L and 47 mg/L, respectively. Maximum levels of ammonia-N from the poultry lagoon spill were 1.2 mg/L, while levels of ammonia reached 45.2 mg/L from the hog lagoon spill. Maximum levels of soluble orthophosphate phosphorus reached 6.9 mg/L from the poultry spill, and 11.5 mg/L from the hog spill. Fecal coliform levels as high as 14,000 and 1,700 CFU/100 mL were measured from the poultry and hog lagoon spills, respectively. The hog lagoon spill into a stream at low flow conditions caused serious increases in chlorophyll a and phytoplankton blooms.

Table 8: Extreme Values Measured in North Carolina Streams after Manure Lagoon Spills.

Water Quality Parameter	Poultry Lagoon Spill	Hog Lagoon Spill
	mg/L	
Dissolved Oxygen	0.3	0.1
Total Kjeldahl Nitrogen	92.1	47.0
Ammonia-N	1.2	45.2
Orthophosphate	6.9	11.5
Chlorophyll a	0.006	0.1

Westerman and Overcash (1980) compared runoff of pollutants from a dairy open feedlot and a pasture irrigated with dairy lagoon waste. Runoff from the feedlot was 21% of the precipitation, while runoff from the pasture was 10% of precipitation. Water quality impacts of the pasture were less than the impacts of runoff from the feedlot, as shown by the mean concentrations of various pollutants in runoff (Table 9):

Table 9: Nutrient Concentration in Runoff from a Dairy Feedlot and Manured Pasture.

Parameter	Dairy Feedlot	Manured Pasture
	mg/L	
Chemical Oxygen Demand	1185	181
Total Kjeldahl Nitrogen	76	13.2
Nitrate-Nitrogen	4.5	8.0
Total Phosphorus	34	7.2

There are several important conclusions that can be drawn from references in this section:

- The impacts on surface water quality and aquatic life from manure lagoon spills, feedlot runoff, and applications of manure to frozen ground can be devastating.

- The number of documented serious water quality pollution problems involving manure lagoon spills and feedlot runoff is generally several tens of events per year in each of the states with high concentrations of feedlots.

- Compared to the several thousands of feedlots in most states, the number of water quality pollution problems causing documented fish kills from lagoon spills and feedlot runoff is typically a small fraction of the total number of operations. An exception to this is the Chesapeake Bay area, where feedlot spills and runoff generate a large fraction of the water quality pollution problems.

Effectiveness of Surface Quality Remediation Strategies in Various Watersheds

A frequently asked question pertains to the length of time required to restore polluted lakes and rivers by implementing best management practices in the contributing watershed. Although not requested by the scoping questions, we undertook a literature review of case studies in which the effectiveness of watershed restoration activities to correct water quality problems resulting from animal agriculture was documented. There are many such case studies published as project reports and agency documents which were not reviewed here because they are not a part of the peer reviewed scientific literature. These could be reviewed at a later stage of the GEIS process, if needed.

Garrison and Asplund (1998) studied the effect of reducing phosphorus loadings on lake water quality in a 3003 ac Wisconsin watershed. Phosphorus losses from animal waste storage facilities were reduced by 46% and from cropland runoff by 19%, but these improvements had a negligible impact on water quality of a lake at the mouth of the watershed. Total phosphorus levels in the lake increased from 29 ppb before implementation of pollution control measures to 44 ppb fifteen years after implementation. Chlorophyll a levels increased from 9 to 13 ppb over the same time period. The increased impairment of the lake after reductions of phosphorus losses was due to a failure to control cropland runoff adequately, which accounted for 76% of the phosphorus loading.

Gallichand et al. (1998) attributed 90% of the point source pollution in the Belair River watershed near Quebec to leaking liquid manure tanks and manure piles. Improved manure storage facilities and septic tanks, and electric fences near streams were installed throughout a 1,310 ac experimental watershed to improve water quality. In addition, fertilizer applications were reduced, fall application of manure was reduced from 70% to 13%, and spring and summer applications were split. No improvements were made in an adjacent control watershed. Maximum concentrations of total phosphorus and dissolved phosphorus decreased significantly in the experimental watershed, but not the control watershed, during two years of monitoring

after improvement. Fecal bacteria counts were not measurably affected by the watershed improvements. In spite of the improvements, total phosphorus concentrations in the improved experimental watershed still exceeded critical levels (0.03 mg/L) for protection of aquatic life 94% of the time.

Hession et al. (1995) stated that the threshold between eutrophic and mesotrophic lakes occurs at 10 ug/L chlorophyll a. Total Maximum Daily Load (TMDL) values for total phosphorus in an Oklahoman watershed were obtained by adjusting annual load using a water quality model until chlorophyll a levels were reduced to 10 ug/L, giving a TMDL of 587 lb P/day. The model predicted that doubling the mass of total phosphorus spread on land from manure would increase chlorophyll a from 10.4 to 10.9 ug/L. Nonpoint sources generated 75% of the total phosphorus loading to the watershed. To meet TMDL values through control of only point sources of phosphorus would require a 72% reduction in point source discharges of phosphorus. To meet TMDL values only through control of nonpoint sources would require a 22% reduction in phosphorus applied to the land.

Schuler (1996) described the restoration of Lake Shaokatan in southwestern Minnesota. This lake was heavily impaired by excessive nitrogen and phosphorus levels, and had nuisance algal blooms and algal toxins which occasionally caused the death of cattle and dogs who drank from the lake. It was determined that a significant proportion of the nutrient load to the lakes was generated by three swine operations and one dairy farm. After corrective measures were taken in 1993 to reduce nutrient loads from these operations, the lake water quality improved significantly. From 1994 to 1996 the average lake total phosphorus concentrations decreased from 270 ppb to less than 160 ppb. Noxious algal blooms and algal scums also disappeared.

These studies indicate that the success in cleaning up water quality degradation due to animal agriculture depends on accurate identification of the source of pollution. Addressing manure waste lagoon spills and feedlot runoff when runoff from manured lands is the major pathway for pollution will not lead to successful cleanup. Similarly, addressing runoff from manured lands will not lead to successful cleanup if lagoon spills and feedlot runoff are the major sources of impaired water quality. In the best case, restoration of water quality can occur in as little as a few years, in the worst case water quality may never be restored if the major sources of pollution are not addressed.

Causes of Impairment for Ground Water

Impact of Various Land Uses on Ground Water Quality

Ground water is an important source of drinking water, particularly for rural residents. Nitrate-N concentrations in excess of 10 mg/L in drinking water are associated with the often fatal blue-baby syndrome (methemoglobemia). Sources of nitrate contamination of drinking water can include fertilizers, animal waste, and human waste. Ground water can also become contaminated with pathogens that cause illness in humans (see this report, scoping question #4 for additional details). Sources of pathogens in drinking water can include animal waste, wildlife

waste, and human waste. The following section discusses the impact of animal manure on ground water quality.

Andres (1995) studied nitrate leaching to ground water in Sussex County, Delaware, which has the greatest number of chicken broilers in the U.S. Soil loading rates from nitrogen in manure averaged 241 lb/ac. Fertilizer nitrogen was applied at an average rate of 43 lb N/ac. Ground water wells exceeded the nitrate drinking water standard of 10 mg/L 20% of the time. The median nitrate concentration was 9.8 mg/L in intensive poultry areas and 5.8 mg/L in areas without intensive poultry. This study shows that intensive animal agriculture on coarse textured soils can lead to nitrate levels in ground water that frequently exceed the drinking water maximum contaminant limits.

Richards (1997) showed that nitrate levels in ground water from Ohio, Indiana, Illinois, Kentucky, and West Virginia were strongly correlated with (in decreasing level of impact) well depth, history of well water levels, type of well, proximity to rivers, proximity to cropland, proximity to barnyards, and lawn chemical usage. Cropland effects were much more significant than proximity to barnyards or usage of lawn chemicals.

Rural ground water wells often show simultaneous contamination by nitrates and fecal coliform (Fedkiw, 1992), because of barnyards, silos, feedlots, buried or stacked organic material, and septic system effluent near fractured well linings or casings, old wells, and poorly located wells. This means that quite often, the pathway for well contamination is flow from surface soils directly down well linings or casings, rather than leaching through soil to ground water.

Huysman et al. (1993) studied the polluting effects of manure on ground water by tracking tetracycline and oleandomycin resistant Clostridium perfringens in shallow ground water below (pig) manured versus unmanured sandy plots. Counts of antibiotic resistant Clostridium as high as 100 CFU/100 mL were detected below manured plots, while they were nearly absent below unmanured plots.

McMurry et al. (1998) studied fecal coliform transport through soil amended with poultry manure. They found that coliform were transported primarily through macropores. Tillage practices which disrupted macropore continuity delayed the transport of fecal coliform, without reducing peak concentrations appreciably.

We can conclude from the references in this section that many factors influence contamination of ground water by nitrates or fecal bacteria. These factors include the depth and condition of the well, the type of soil and geologic material above the aquifer, the location of the well, the land use surrounding the well (particularly cropland), and the density of animals and manure handling and application practices. Ground water contamination from animal agriculture is most likely to occur when intensive animal agriculture occurs in regions having coarse textured soils, shallow ground water, and heavy precipitation.

Impact of Manure Storage Facility Seepage on Ground Water

In addition to the problem of land applied manure, ground water can become contaminated when manure storage basins leak, causing nutrients in the manure to leach downward towards ground water. The reasons why this problem occurs and the factors which promote it are reviewed below.

Miller et al. (1985) studied self-sealing of earthen liquid manure storage ponds, and found that a seal usually formed within 12 weeks of construction. McCurdy and McSweeney (1993) found that earthen-lined dairy manure storage basins had seepage losses primarily because of freezing, earthworm activity, roots, and pedogenesis. Most of the pollutants were lost to ground water through macropores in the sidewalls.

Ciravolo et al. (1979) studied the factors associated with leakage of wastes from anaerobic swine lagoons in Virginia on sandy and sandy loam or sandy clay loam soils. Leakage was minimal for lagoons on sandy loams with finer texture subsoils. Leakage was significant for the lagoon in sandy soil. Failure of the seal was related to drying of the lagoon bottom during excessive pumping of waste, and release of gas from below the seal. No contamination of ground water at any location by fecal coliform, copper, phosphate or zinc was observed. Contamination by chloride (max conc. 272 ppm), ammonium-N (max conc. 358 ppm), and nitrate-N (max conc 100.8 ppm) was considerable for the lagoon on sandy soil.

Culley and Phillips (1989a) monitored nitrogen and phosphorus seepage beneath earthen manure storage pits constructed in sand, sandy loam, and clay loam. Depth averaged orthophosphorus concentrations monitored during four years increased from less than 10 ppb to over 250 ppb beneath the pit constructed in sand, while nitrate-N concentrations increased from less than 5 ppm to over 50 ppm. Seepage losses were much less for pits constructed in sandy loam and clay loam soils.

Culley and Phillips (1989b) found that the factors controlling nitrate-N seepage from unlined earthen manure storage pits included the saturated hydraulic conductivities of the soil and the pit seal, the height of the water table, and the rate of decrease for hydraulic conductivity in unsaturated soil beneath the pit. Leakage rates were significantly greater for pits constructed in coarse textured soils than in fine textured soils.

Ritter and Chirnside (1990) studied clay-lined anaerobic lagoons constructed in sandy loam or loamy sands and containing hog or beef waste. Seepage beneath the hog lagoon was due to drying and cracking of the liner after liquid levels were pumped below design levels. Average ammonium-N and nitrate-N concentrations beneath the seeping hog lagoon were 968 and 40.5 mg/L, respectively. Limited seepage was observed beneath the beef waste lagoon, where average ammonium-N and nitrate-N concentrations were 12.1 and 9.1 mg/L, respectively.

Wall et al. (1998) studied seepage from a 600,000 gallon clay-lined earthen manure storage system for a 100 cow dairy operation in central Minnesota. Seepage averaged 5 gal/d from the bottom and 102 gal/d from the sidewall during the first 3 years of operation. The main

contaminants leached were sodium and chloride, with very small fractions of nitrogen and phosphorus leached. Monitoring of 13 newly constructed earthen basins and lagoons in Minnesota found little evidence that seepage was affecting ground water at 12 of the 13 sites.

We conclude that, under certain circumstances, seepage from manure holding basins and lagoons can have a very serious impact on ground water quality, especially from nitrate-N and ammonium-N. These impacts are greatest with unlined earthen manure storage systems, and lined pits constructed in coarse textured soils. Seepage losses generally occur when the sidewalls become cracked or develop macropores. Lined basins and lagoons which are properly constructed, engineered, and managed are generally not a serious threat to ground water quality, unless constructed in coarse textured soils or karst terrain. Unlined earthen manure storage systems may develop a slowly permeable seal after several weeks of operation, but generally pose a much greater risk for pollution of ground water by seepage than lined storage facilities.

Animal waste from feedlots can get into the ground water via many potential routes, including the following:

- Continual leakage of waste lagoons/basins or pits, where:
  -clay-lined and unlined earthen basins or pits develop root cracks, wetting/drying cracks, secondary soil structures, erosion of the bottom or sides from agitation or scraping by equipment when cleaning out the basins, etc.;
  -concrete basins or pits develop structural cracks (such as from differential settling), and/or chemically corrode from the waste;
  -plastic-lined basins or pits leak along poorly sealed seams, or where punctured from rocks, equipment, etc.
  -unknown tile lines exist below a basin or pit, which forms a direct hydraulic conduit to the ground water.

- The potential for basin leakage to a drinking water aquifer is significantly increased in areas of geological susceptibility.

- Episodic waste release from lagoons/basins, pits, or waste-handling equipment can develop from:
  -waste-handling spills;
  -overtopping of the basins or pits;
  -catastrophic failure of the basin sidewalls or dikes, such as by penetration by cleaning equipment;
  -hydraulic failure from excessive water pressure such as during flooding events or if tile lines cannot keep ground water levels low enough;
  -erosion (soil piping) and subsequent failure of the basin sidewalls or dikes.

- Releases to ground water can occur from land application of the wastes due to:
  -disposal of manure by over-application (above agronomic rates) in restricted areas;
  -application over tile drains, surface inlets, sinkholes, undetected focused recharge areas, etc.;
  -routine application at approved agronomic rates on fields that have already received other fertilizers.
  -all of the above ground water contamination potentials are aggravated when heavy rains occur shortly after the land application.

The most difficult problem in detecting contamination is in ground water contamination because it is usually an " invisible" problem; only rarely are there obvious signs of basin, lagoon, or pit deterioration during normal use. The second most difficult problem with ground water contamination is that it is usually detected only after the fact. Therefore, an aquifer can be seriously impacted before it is known.

2. How is the use of water by humans for drinking, recreation, and other purposes affected by water quality degradation?

There are two approaches for assessing the degree to which surface waters are degraded by pollution, namely; by evaluating existing water uses and quality using narrative and numerical criteria. Narrative criteria usually address questions such as:

- Are the fish safe to eat?
- Are opportunities for fishing and boating limited by pollution?
- Is it safe to swim in the river or lake?
- Are there noxious aquatic plants or algae?

Numerical criteria are framed in terms of water quality standards. These standards vary depending upon the type of classification for the waterbody. Lakes and rivers are classified according to their potential uses. The primary use classifications for Minnesota lakes and rivers include (Minnesota Rules 7050):

- AClass 1C waters. The quality of Class 1C waters of the state shall be such that with treatment consisting of coagulation, sedimentation, filtration, storage, and chlorination, or other equivalent treatment processes, the treated water will meet both the primary (maximum contaminant levels) and secondary drinking water standards issued by the United States Environmental Protection Agency. The primary drinking water maximum contaminant level (MCL) of interest here is that nitrate-nitrogen levels will not exceed 10 mg/L. This standard applies whether the source of drinking water is from surface or ground waters.

- AClass 2A waters. The quality of Class 2A surface waters shall be such as to permit the propagation and maintenance of a healthy community of cold water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface waters is also protected as a source of drinking water.

- AClass 2Bd waters. The quality of Class 2Bd surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface waters are also protected as a source of drinking water.

- AClass 2B waters. The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface water is not protected as a source of drinking water.

- AClass 2C waters. The quality of Class 2C surface waters shall be such as to permit the

propagation and maintenance of a healthy community of indigenous fish and associated aquatic life, and their habitats. These waters shall be suitable for boating and other forms of aquatic recreation for which the waters may be usable.

Drinking Water

Drinking water for 1 million Minnesota residents of the Twin Cities metropolitan area originates primarily in the surface waters of the Upper Mississippi River basin. Many residents of south central Minnesota and the Red River basin also derive their drinking water from surface water sources. Many rural residents in southwestern, southeastern, and central Minnesota derive their drinking water from ground water wells. About a million Twin Cities metropolitan area residents also derive their drinking water from ground water wells.

One of the greatest concerns for water quality is the problem of drinking water contamination from pathogens. The 1994 Cryptosporidium outbreak in Milwaukee sickened 403,000 people and cost $37 million in lost wages due to sickness (Smith, 1994). The water treatment plant was not operating properly during the Milwaukee Cryptosporidium outbreak due to high turbidity. It is not known whether the source of the cysts was human sewage, livestock along the rivers, or slaughterhouses.

Le Chevallier et al. (1991) surveyed 66 U.S. surface water treatment plants mostly located in Pennsylvania, W.Virginia, Ohio, Indiana, and Illinois for Giardia and Cryptosporidium cysts in drinking water. Giardia cysts were found in 81% of the untreated and 17% of the drinking water samples, while Cryptosporidium cysts were found in 87% of the untreated and 27% of the drinking water samples. Either Giardia or Cryptosporidium cysts were found in 39% of the samples. Concentrations of cysts for both Giardia and Cryptosporidium were highly correlated with fecal coliform levels and turbidity.

Several typical water treatment methods were evaluated for their effectiveness in removing cysts. It was found that granulated activated carbon filter systems had cysts 61% of the time, while sand, mixed-media, or dual-media filters had cysts 17 to 36% of the time. Removal of cysts was strongly enhanced by reductions in turbidity during the treatment process. Most of the cysts remaining in finished drinking water were nonviable and inactivated, meaning that settling, filtration, and chemical treatment of water contaminated by cysts typically results in drinking water that is not a human health hazard. These treatment processes do not always operate at maximum efficiency during periods when thereare high turbidity levels, and it is during these times that a human health risk from cysts may occur.

The Minneapolis water treatment plant is currently considering enhanced filtration and treatment techniques to address concerns for Giardia and Cryptosporidium in drinking water for the Twin Cities metropolitan area. Pell et al. (1994) states that Giardia cysts in public drinking water caused 18% of the water borne gastroenteritis between 1971 and 1985 in the U.S. The American Society for Microbiology (1999) states that up to 900,000 illnesses and 900 deaths occur each year from waterborne microbial infections. By law, drinking water plants must

remove 99.9% of giardia cysts using water supply protection, disinfection, and filtration.

There have been 14 documented incidents of cryptosporidium disease outbreaks in U.S. and Canada since 1984 (Frey et al., 1998). Four of these events were linked to nonpoint source agricultural pollution, the others were primarily caused by septic tank and human sewage contamination. The primary sources of cryptosporidium protozoa include wildlife, domestic livestock, and humans. Young calves (1-3 weeks old) are most likely to carry the cysts, and should be kept in clean and dry housing. About 59% of all beef and dairy farms have cryptosporidium in livestock. Cryptosporidium cysts in livestock manure can be inactivated by drying, liming, and composting. Manure from infected calves should not be placed on land near water or on frozen soils.

Ground Water

There are roughly 450,000 private wells used to supply drinking water to Minnesota residents. Wall (1991a) estimates that roughly 7% of these wells have nitrate-N levels exceeding the maximum contaminant level (MCL) of 10 mg/L. There are another roughly 1,700 public community water supply wells in Minnesota, of which roughly 1% have nitrate levels greater than the MCL.

The percent of these contaminated wells that are affected by animal agriculture is unknown. It is known that several pathways exist for contamination of ground water by animal agriculture (Wall, 1991b), including:

- Direct leaching from outdoor animal holding areas
- Runoff and subsequent infiltration
- Runoff into unused wells, improperly sealed wells, and sinkholes
- Runoff to surface water that eventually discharges to ground water
- Leaching beneath manure storage areas
- Application of manure in excess of crop nutrient uptake requirements
- Leaching beneath abandoned feedlots
- Leaching from animal burial pits or improper composting of dead animals

See the response to scoping question #6 for a state-wide summary of ground water contamination patterns by nitrate.

EPA 305(b) Summary Reports on the Quality of Lakes, Rivers, and Streams

The U.S. Environmental Protection Agency (EPA) under Section 305(b) of the Clean Water Act requires states to assess and estimate the extent to which waterbodies meet the goals of the Clean Water Act and attain water quality standards. A note of caution is warranted for EPA 305(b) reports. These reports are based only on surveyed or monitored waterbodies, which may be a small proportion of all existing waterbodies. Furthermore, the waterbodies selected for survey and monitoring may be biased towards the most polluted waterbodies.

Results from the 1996 nationwide 305(b) survey are reported below in terms of the total miles surveyed which fully support, are threatened, partially support, do not support, or cannot attain these goals and standards. For simplicity, waters are given a summary use support classification of good (fully supporting all uses or threatened for one or more uses) or impaired for one or more uses (not supporting, or not attaining).

Table10: Nationwide 305(b) Report (1996 Summary)

Report Factor	Rivers and Streams	Lakes
Total Extent of Waterbodies	3.6 million miles	41.7 million acres
Surveyed Extent of Waterbodies	0.7 million miles	17 million acres
Waterbodies with Good Status	64%	61%
Waterbodies with Impaired Status	36%	39%

Roughly 19% of all rivers and streams, and 40% of all lakes (excluding the Great Lakes) were surveyed in 1996 (Table 10). Of the surveyed waterbodies, 64% of the rivers and streams, and 61% of the lakes were classified as good quality. Overall, agriculture was the leading source of pollutants and stressors in 25% of surveyed rivers and streams, and in 19% of surveyed lakes.

The remaining 36% of rivers and streams, or 39% of lakes were classified as impaired, meaning that they did not support or could not attain the goals and standards set forth in the Clean Water Act and state regulations. The primary cause of impairment in 70% of the rivers and streams classified as being impaired was agriculture. Of these agriculturally impacted rivers and streams, non-irrigated cropland production was the leading cause of impairment (36%), followed by irrigated cropland production (22%). Other causes of impairment (Table 11) were rangeland (12%), pastureland (11%), feedlots (8%), animal operations (7%), and animal holding areas (5%). Animal agriculture can indirectly influence the impact on surface water quality from

Table 11: Type of Agricultural Activity	% Contribution to Impairment in Rivers and Streams from All Agricultural Sources
Non-irrigated Cropland Production	36
Irrigated Cropland Production	22
Rangeland	12
Pastureland	11
Feedlots	8
Animal Operations	7
Animal Holding Areas	5

both irrigated and non-irrigated cropland production through land applications of manure, so the impacts of animal agriculture on surface water quality may be underestimated based on the reporting method used for data in Table 11.

The Minnesota Pollution Control Agency assesses the ability of state surface waters to support swimming and aquatic life on a five year cycle. Reports on use support have been completed for the Minnesota River and the Red River basins. These assessments are consistent with the two major goals of the Clean Water Act, to ensure that surface waters are swimmable and fishable. The assessments are based upon narrative and numeric criteria described in the previous section, and waters are classified into fully supporting, partially supporting, supporting but threatened, or not supporting the beneficial uses.

Table 12: Minnesota 305(b) Report (1994 Summary)

Report Factor	Rivers and Streams	Lakes
Total Extent of Waterbodies	91.9 thousand miles	3.3 million acres
Surveyed Extent of Waterbodies	12.2 thousand miles	2.4 million acres
Waterbodies with Good Status	40%	83%
Waterbodies with Impaired Status	60%	17%

In the state of Minnesota, 31% of the rivers and streams and 73% of the lakes were surveyed and/or monitored for the 1994 305(b) report (Table 12), the last year for which statewide data summaries are published. Of the surveyed and monitored waterbodies, about 60% of the rivers and streams, and 17% of the lakes were classified as being impaired. Agriculture was identified as the cause of 90% of the impaired river miles, and 64% of the impaired lake acres. No additional information was available on the degree to which various types of agricultural activities (cropland, feedlots, rangeland, etc.) caused impairment. Besides agriculture, other causes of nonpoint source pollution included land disturbance, habitat modification, urban areas, and construction activities.

Rivers

Results from the 1996 assessment for the Minnesota River (Senjem, 1997) indicate that its tributaries are generally poor in supporting the aquatic life that would be found under natural conditions. Conditions are very poor for swimming in the tributaries. In general, the support for aquatic life is better in the mainstem of the Minnesota River than its tributaries. The following table summarizes the assessment of rivers in the Minnesota River basin.

Table 13: Percent assessed miles of tributaries to the Minnesota River not supporting beneficial uses for swimmability and fishability based on assessment by the Minnesota Pollution Control Agency (Senjem, 1997).

Tributary	Aquatic Life	Swimming
	----------Percent Not Supporting----------	
Pomme de Terre	64	100
Lac Qui Parle	52	100
Chippewa	95	100
Redwood	61	100
Cottonwood	62	100
Blue Earth	80	100
Watowan	77	100
Le Sueur	97	100

These results show that from 50-100% of the assessed tributary river miles in the Minnesota River basin do not adequately support aquatic life. This results in reduced diversity of fish and other aquatic life, and predominance of undesirable fish species. None of the tributaries is fit for swimming, primarily because of high levels of fecal bacteria.

The most common indicators of impairment in the tributaries of the Minnesota River basin included oxygen depletion, turbidity, bacteria, and habitat alteration. The most common suspected pollution sources were agricultural nonpoint sources, hydrologic modifications, urban runoff, and land disposal of wastes. Impacts from municipal discharges and construction activities were less common sources of pollution. No information is available to specifically identify the miles of streams and rivers impacted by animal agriculture.

Lakes

Over eighty percent of the lakes in the Minnesota River basin were also assessed. Only 38% of the lakes fully support swimming. Of assessed lakes, 40% did not support swimming. More information on degradation of lakes is provided in the response to question 6.

3. Impacts of livestock management on fish and wildlife

There are many reports in the literature which suggest that well-managed livestock grazing is compatible with a healthy riparian ecosystem but that practices and their impacts should be viewed as site specific testable-hypotheses rather than generic practices to be widely applied (Clark, 1998). It is to be expected that grazing and riparian systems should be compatible to some degree. Prairie ecosystems had large numbers of bison for thousands of years (Bradley and Wallis, 1996). However, those bison probably were migratory and did not concentrate in the riparian areas. Clearly, they had great impact during their migrations; however, after a relatively short and intense impact on a specific area, they moved on allowing riparian zones and in-stream communities to recover (Fitch and Adams, 1998)

Today, impacts of livestock grazing on stream and riparian ecosystems are widespread; for recent reviews see Kauffman and Kreuger (1984), Platts (1991), Fleischner (1994), Knapp and Matthews (1996). Much of the better known impact has been reported from the western United States. For example, a survey of stream riparian zones which rated conditions on a poor-good scale (Table 14) found widespread disruption of stream ecosystems.

Table 14: Percent of stream riparian condition reported to be in poor, unsatisfactory and/or fair condition (Armour et al., 1994).

Location	Percentage	Condition
Tonto National Forest, Arizona	80-90%	Unsatisfactory
Modoc National Forest, California	78%	Unsatisfactory
Sawtooth National Forest, Idaho	37%	Poor
One Ranger District in Nevada	90%	Poor
One Ranger District in Baker Oregon	60%	Poor to Fair

Damage to riparian zones and streams has been widely addressed (e.g., Leopold, 1975; Armour, 1977; Behnke, 1977; Kennedy, 1977; Marcuson, 1977; Van Velson, 1979; Claire and Storch ,1983; Duff, 1983). In general, that damage includes loss of riparian vegetation and resulting alterations of stream morphology, a lowered groundwater table and decreased dry season stream flow, increased summer water temperature and increased substrate icing in winter (Armour et al., 1994).

It is widely recognized that poorly managed grazing results in degradation of riparian areas (Fitch and Adams, 1998). However, we know relatively little about the specific livestock practices which result in specific impacts. Further, very little evidence of livestock impacts clearly relates to Upper Midwestern water bodies. For example, Larsen et al. (1998) reviewed more than 1500 scientific papers dealing with livestock management. They report that 428 of those articles were directly related to grazing impacts on riparian zones and fish habitat. Of those,

only 89 were experimental, where treatments were replicated and results were statistically valid. They concluded that there are several limitations of riparian grazing studies, including (1) inadequate description of the grazing management practices or treatments, (2) weak study designs, and (3) lack of pre-treatment data (Larsen et al., 1998). It was not clear that any of those 89 instructive papers dealt with Midwestern streams, nor that results from Intermountain West conditions are applicable to Minnesota.

From the cited literature reviewed in this section we can conclude the following:

- Un-managed or poorly managed livestock practices result in riparian degradation and significant impacts on fish and wildlife.
- There is little conclusive evidence in the literature about the degree of impact expected from specific livestock practices
- More significantly for our purposes, very little of the existing scanty evidence is clearly relevant to Upper Midwestern water bodies.

Riparian zones and their adjacent water bodies

Riparian areas are ecotones (i.e., edges between two systems of different character) and they have high edge to area ratios (Odum, 1978). As such, they are very " open" ecosystems, with large energy, nutrient and biotic interchanges with aquatic systems on inner margin (Cummins, 1974; Odum, 1978; Sedell et al., 1974) and upland terrestrial area (Odum, 1978). Riparian zones have much higher diversity and productivity than do the adjacent uplands. Streams and wetlands in the forested areas of Minnesota are heterotrophic, depending on external sources for their carbon. In such systems, the riparian produces detritus that drives up to 90% of secondary productivity in the stream (Cummins and Spengler, 1978; Kauffman and Kreuger, 1984). Waters in the more open areas of Southwestern Minnesota are autotrophic, having greater levels of in-stream productivity. However, they are equally dependent on the character of their riparian zones (Perry and Vanderklein, 1996).

Overall, the riparian /stream ecosystem is the most productive type of wildlife habitat, benefitting greatest number of species (Ames, 1977; Hubbard, 1977; Miller, 1951; Patton, 1977). Riparian zones which had their vegetation removed and rip rap placed along the shore line had 93% fewer bird numbers and 72% fewer bird species. In other nearby riparian areas which were cultivated, there were 95% fewer birds and 32% fewer bird species (Kauffman and Kreugger, 1984)

Sediment, nutrients and organic matter

Sediment is the most prevalent aquatic pollutant in streams in North America (Waters, 1995; See Question 5 for review). We know that livestock management often causes changes in sediment load, nutrient content and organic matter in streams and may cause changes in lakeshores. There is some evidence that sediment and nutrients associated with livestock has a negative impact on fish and invertebrates (See below). However, those finding have most

frequently been reported from the semi-arid areas such as the western and southwestern parts of the US. We have very limited data on the specific contributions of various livestock management practices in the Midwest.

Impacts of livestock management on fish and wildlife habitats

Fish, amphibians, birds and insects rely on water's edge habitats (e.g., undercut banks, overhanging vegetation) for habitat and food. Cattle trample banks, caving in overhangs and creating erosion (Trimble and Mendel, 1995). If livestock management changes those habitats, impacts to the populations will be seen. Williams et al. (1992) found that there were differences in vegetation overhang, aquatic habitat and recent erosion in some of the grazed and retired reaches in their New Zealand streams but these results were highly site specific.

In a similar recovery study, Meyers and Swanson (1996) compared the recovery from abusive grazing in Nevada streams. They measured and found that bank stability, defined as the lack of apparent bank erosion or deposition, improved through the recovery period on both streams. However, periodic grazing and flooding decreased stability more on Summer Camp Creek than flooding alone on Mahogany Creek. Their conclusion was that grazing exacerbated the natural variation due to flooding and stream bank erosion.

Grazed areas consistently have reduced canopy shading, stream depths and bankfull heights and greater stream widths than do ungrazed streams (Knapp and Matthews, 1996). The degree to which that geomorphological change is evident is dependent on grazing intensity. In at least one instance (Hayes, 1978), slough-off or bank caving due to cattle passage increased as forage removal exceeded 60%; below 60% removal, banks remained stable (Kauffman and Kreuger, 1984)

Large woody debris (LWD) is a very important element of stream ecosystems. It provides stable substrate, diverts the energy of the water, offers some carbon and energy resources, and structures local habitat (Davis and Perry, In Preparation).We did not find evidence that cattle grazing changed density or quality of LWD in Midwestern streams. In some cases (e.g., in Nevada) in-stream habitat quality was decreased under grazing conditions because LWD was removed from streams due to the increased " flashiness" of the hydrology; this was reversed when a riparian area was released from the pressures of grazing. In that latter case, tree cover increased as much as 35% (Meyers and Swanson, 1996). It is apparent that cattle grazing increases fine sediment deposition in stream reaches with high volumes of large woody debris (Sidle and Sharma, 1996).

Although nearly all of the grazing literature deals with streams, lakes and lakeshores are critical habitat in Minnesota. At least one study has examined the impacts of livestock grazing on lakes. They concluded that, although heavy grazing of lakeshores is clearly detrimental to marginal vegetation, low levels of grazing may be an appropriate management tool in areas of some lakes. In these latter situations, grazing will damage some local vegetation patches, but overall promote more diverse inshore habitats for plants and wildlife (Tanner, 1992).

From the literature reviewed in this section we can conclude the following:

- Cattle (and perhaps other livestock) increase streambank erosion, reducing habitat availability for both terrestrial and aquatic animals
- Large woody debris in and near the stream channel is a major component of habitat and its prevalence is usually decreased in grazed areas
- We have limited information suggesting that lakeshores and larger rivers are significantly less susceptible to impact than are streams.

Impacts of livestock management on macroinvertebrates

Macroinvertebrate animals, primarily insects represent critical elements of the aquatic ecosystem. They are a highly diverse community, they represent ecosystem biodiversity, they serve as fish food, they perform a wide range of ecosystem functions such as energy and nutrient cycling, and they are valuable indicators of ecosystem health (Perry and Vanderklein, 1996). In 1988, Rinne said " Studies on how grazing impacts aquatic invertebrates are nonexistent in the literature" . Although that is not true today and indeed was not true in 1988, it does demonstrate that we really do not know enough about invertebrate responses to grazing.

Impacts on macroinvertebrate densities

We know that land clearing for pasture leads to hill slumping and siltation. That silt buries the lateral bars along the stream channels, rendering this habitat unsuitable for invertebrates. Some of the most important habitats and most important invertebrate communities are in the hyporheos, the interstices among the rocks below the stream bottom. That community is (or can be) negatively impacted by livestock. For example, Boulton at al. (1997) found that the vertical depths of the hyporheic zones along the thalweg at two pasture sites were significantly less than those at exotic pine and native forest sites. There was no evidence in their study to support the related hypothesis that the hyporheic zone of pasture sites contained more fine sediment. However, fewer individuals and taxa occupied the hyporheic zone of streams draining pasture than other sites, and with some important groups such as water mites were completely absent (Boulton et al., 1997).

Terrestrial invertebrates are an important food source for fishes, and they are dependent on the quality and structure of riparian vegetation. In New Zealand streams, the mean biomass and numbers of terrestrial invertebrates that entered tussock grassland and forest streams was more than three times the biomass that entered pasture streams. Mean abundance and richness of terrestrial invertebrates drifting in the stream (and therefore more readily available to the fishes) was not significantly different among land-use types (Edwards and Huryn, 1996)

In a study comparing stream reaches which were and were not subject to grazing, Wohl and Carline (1996) found significant negative impacts on benthic invertebrates. One and a half miles along Cedar Run and 2.5 mi along Slab Cabin Run were subject to grazing pressure; there

was no riparian grazing along Spring Creek, the reference stream. Densities of benthic macroinvertebrates were significantly higher in Spring Creek (the reference condition) than in the other streams. Although there were marked differences in stream communities among streams with and without riparian grazing, the authors admit that other watershed attributes could have had some influence on these streams. There was inadequate experimental control to rule out extraneous influences.

Although we cannot demonstrate clear relationships between a variety of grazing densities or other livestock management activities and stream impacts, we agree with Rinne (1988) that macroinvertebrates may be more suitable than fish for detecting grazing impacts, primarily because they are more diverse and more easily sampled and analyzed.

There have been isolated reports of other problems with the integrity of the aquatic ecosystem under grazing conditions. For example, elevated concentrations of nutrients downstream of pastures caused increased growths of filamentous bacteria. This is a common situation in many nutrient enrichment conditions, such a below sewage outfalls. However, in at least one instance in a grazing study, those bacteria were reported to colonize the gills and body surface of aquatic insects. As a result, there were significantly lower densities of insects (up to 66% less) at downstream sites and those insects that were present were unhealthy (Lemly, 1998).

Impacts on macroinvertebrate species composition

The specific composition (i.e., numbers of species as well as specific species presence and absence) can serve as an indicator of some impacts. The hyporheos of some streams subject to grazing, for example contained fewer taxa (i.e., reduced " richness") and fewer individuals. The hyporheos was dominated by ostracods, nematodes and elmid larvae. The former two taxa are frequently found in the hyporheos but elmids are typically eppigean (i.e., cave-dwelling). Water mites, commonly found in the hyporheos of most streams were conspicuously absent from pasture sites (Boulton et al., 1997) indicating that conditions were outside their levels of tolerance.

Under conditions where grazing was excluded for a decade, aquatic macroinvertebrate populations were markedly different in density and biomass. Grazed sites had increased densities and biomass of tolerant forms and strikingly reduced overall densities and biomass of total invertebrates. There were also significant differences in " community composition" , as seen by biotic condition and mean chi square indices. All metrics together indicated that the invertebrate community in the grazed areas was significantly impacted (Rinne, 1988).

The ways that aquatic invertebrates gather food and process energy is indicative of the role they play in the community. If we group all organisms which process energy in a similar way, we can develop Functional Feeding Groups (Perry and Vanderklein, 1996). Such grouping allows us to evaluate the degree to which the stream function has been impacted by some practice. We would expect to see that shredding and collecting were the predominant insects in most streams where the riparian zone is healthy and grazing impacts are minimal. Higler and

Repko (1981) found just such a situation in the headwaters of a stream, and then detected a significant change in which shredders were significantly reduced and filterers were increased as they moved downstream in a Dutch watershed in which farmers were raising 50,000 calves and in which there was a high concentrations of manure. They further reported that most invertebrates were restricted to higher velocity reaches. These findings offer an avenue for further development of specific monitoring tools that could use Functional Feeding Groups to measure impacts in Minnesota streams.

The structure of the riparian vegetation plays a dominant influence on the health of the macroinvertebrate community; that vegetative structure is strongly influenced by grazing. As others have found however, that relationship is stream-size dependent. For example, in one analysis of small streams (catchment areas 1.2-3.8 mi^2, widths 3.2-13.1 ft), intensive grazing by cattle was shown to greatly reduce shading by riparian vegetation, resulting in substantial increases in daily maximum temperatures during summer. Marked changes in invertebrate communities were associated with those habitat modifications. In general, taxa favored by cool water and low periphyton abundance (e.g., Plecoptera, *Paraleptamphopus caeruleus*, *Deleatidium* sp., and *Helicopsyche albescens*) decreased in density, whereas densities of taxa favored by an abundance of periphyton (e.g., Chironomidae and *Oxyethira albiceps*) increased. In contrast, differences in physical habitat and invertebrate communities were minor between paired grazed and riparian-protected reaches of the larger streams (catchment areas 3.8-12.7 mi^2, median widths 19.7-52.5 ft) where grazing had little or no effect on stream shading. The authors conclude that their results indicate that in small streams, with median natural channel widths below about 19.7 ft, the effects on benthic invertebrates *decrease* in the following order: channelization > intensive grazing by cattle > extensive grazing by cattle and/or sheep (Quinn et al., 1992).

From the references reviewed in this section we can conclude that:

- Both terrestrial and aquatic invertebrate densities in streams are reduced when streams are subjected to grazing pressure; recovery of those communities after grazing pressure is removed requires several years to a decade or more
- Livestock impacts are stream-size dependent; invertebrate communities in small streams (e.g., 1st to 3rd order, <16 ft width) are much more susceptible than are those in larger systems
- Invertebrate communities are diverse, productive and relatively well understood; as such, they are more useful as livestock biomonitors than are fish communities.

Effects of livestock on fish and fish communities

There is consensus among many authors that grazing degrades stream fish communities. Brown trout biomass was initially reported to be 31% greater in un-grazed areas in certain Montana streams (Gunderson, 1968). Brown trout biomass was later shown to be 3.4 times greater in same area (Marcuson, 1977). However, both analyses are subject to interpretation because the grazed sections had been cleared by the Corps of Engineers, making comparisons

difficult (Platts, 1988). Storch (1979) reported that game fish were 77% of the total fish population in un-grazed streams and only 24% in grazed systems. However, the sites chosen for comparison were not clearly comparable (Platts, 1988). Starostka (1979) found that trout populations were " about the same" in grazed and un-grazed areas but offered no pre-grazing data as a comparison. Duff (1977) showed trout biomass in enclosures was 3.6 times greater than in an upstream grazed area; however, another area upstream of the grazing has beaver dams and 1.5 times the biomass of the un-grazed area. Keller et al. (1979) showed remarkable aquatic habitat changes after removal of grazing, but had no pretreatment data for comparison.

Wohl and Carline (1996) studied two stream reaches that were subject to grazing: Cedar Run had about 1.6 mi of grazed margin, Slab Cabin Run had 2.5 mi. They were able to use Spring Creek as an un-grazed reference site. They found that densities of wild brown trout were 5-23 times higher in Spring Creek (the reference condition) than in the two grazed streams, Cedar Run and Slab Cabin Run. They conclude that although there were marked differences among streams with and without riparian grazing, other watershed attributes could have had some influence on these streams. These findings are typical in that grazing and livestock impacts to fish communities are " demonstrated" and then the authors (or another reviewer) concludes that the experimental design really did not allow a definitive result. In fact, Platts (1988) concludes that there is a bias in the literature because of poor design, lack of reference and pre-impact data. He suggests that we clearly can see that past grazing has impacted streams, but impacts today are less clear.

In a study of cumulative effects of riparian disturbance by grazing on the trophic structure of high desert trout streams (Li et al., 1994), watersheds with greater riparian canopy had higher standing crops of rainbow trout *Oncorhynchus mykiss*, lower daily maximum temperatures (range, 61-73 degree F compared with 79-88 degree F), and perennial flow. Watershed aspect influenced the response of trophic structure to grazing influences. Standing crops of rainbow trout were negatively correlated with solar radiation and maximum temperature in watersheds flowing northward. A different relationship was observed for a set of watersheds with a southern aspect, perhaps due to the presence of spring seeps and stream desiccation in the heavily grazed stream. Trout biomass was negatively correlated with solar radiation, whereas positive relationships were found for discharge and depth. Algal biomass was positively correlated with solar insolation, total invertebrate biomass, and herbivorous invertebrate biomass in all watersheds. Invertebrate biomass was not significantly correlated with rainbow trout standing crop.

Those riparian impacts affect many aspects of stream fish communities. Stream sections subject to grazing had more spawning habitat and higher Golden trout densities than un-grazed sections (Knapp et al., 1998). That golden trout study population was limited by spawning habitat; spawning habitat availability influenced the production of age-0 trout as well as recruitment into the adult population. Cattle grazing widened the study streams, producing more habitat for the Golden trout. That response probably is related to niche separation, where the Golden trout uses more open areas than its competitors. The increased hydraulic forces from grazed landscapes provided an advantage to the Golden trout, and a disadvantage to other competitors. However, growth rate of the trout was not impacted as expected. Apparently, individual growth rates of Golden trout are negatively density dependent. Therefore, reductions in densities associated with

grazing resulted in grazing-related decreases in trout growth rates (Knapp et al., 1998).

Cedar Run and Slab Cabin Run (described above) showed significant negative impacts on Brown trout (*Salmo trutta*). Compared to the un-grazed Spring Creek, substrate permeability of Brown trout spawning sites was lowered, suggesting reduced population viability (Wohl and Carline, 1996). In other areas, similar impacts to trout spawning have been reported (VanVelson, 1977; Keller et al., 1979)

Non-game fish are critical portions of the fish community and the stream ecosystem but we have little information about livestock impacts on them. On a Kentucky watershed with significant amounts of swine rearing, stoneroller minnows, bluntnose minnows and common shiners, all omnivores, increased in autumn in a downstream direction, fall suggesting nutrient enrichment from the livestock (Hoyt et al., 1994). Van Velson (1979) studied a stream a community eight years after cattle had been excluded. He found that " rough" fish were 88% of community before exclusion and 1% after 8 years exclusion. In contrast, Rainbow trout represented 1% of the total number of individuals before exclusion and 97% after.

Fish kills associated with livestock management

There has been a wide variety and an increasing number of fish kills associated with livestock management in Minnesota in the last several years. However, data about those incidents are sparse and uncoordinated.

One report (Harken et al., 1997) reported that there were more than 40 manure spills in 1996 in Minnesota, Iowa and Missouri; they estimated that those spills killed 670,000 fish. The Minnesota Pollution Control Agency reported on a 100,000 gallon manure spill which killed nearly 700,000 fish in Renville County (Minnesota PCA Press Release, 20 Feb 1998).

The Minnesota PCA (L. Ganske, personal communication, 21 June 1999) provided the following information regarding recent livestock-related fish kills. There were several spills each year that had fish-kill impact (Table 15). However, manure-related discharges are not the most common cause of fish kills (Table 16) and there is a significant difference in the information tabulated by various sources.

Table 15. Minnesota Fish Kills

Year	No.[1]	Location	Summary of impact
1994	1	Mud Creek, Rock County	Killed 200 minnows
1995	2	Medary Creek, Lincoln County Drainage ditch, Lyon County Total reported for year	Killed 19,640 fish Killed 296 fish 19,936 fish
1996	6	Peter Lake, Hennepin County Minnesota River, Hennepin County Marble Creek, Blue Earth County Ditch, Goodhue County Wetland, Meeker County Beaver Creek, Renville County (truck accident)	No fish reported killed
1997	9	East Fork of Beaver Creek, Renville County Speltz Creek, Winona County 130 minnows Total reported for year Incidents also occurred in: Clear Lake, Sherburne County; Minnesota River, Nicollet County Cottonwood River, Lyon County County ditch, Le Sueur County Buffalo Creek, McLeod County Spring Lake, Scott County County ditch, Le Sueur County	Killed 650,000 fish Killed 130 minnows 605,000 fish
1998	10	Beaver Creek, Renville County Dexter Creek, Mower County Buffalo Creek, Sibley County Waterloo Creek, Houston County (fish kill occurred in Iowa) Total reported for year Incidents also occurred in: South Fork of Crow River, Meeker County North Branch Root River, Olmsted County Co. ditch #59, Renville County County ditch, Renville County Blue Earth River, Blue Earth County Beaver Creek, Renville County	Killed 3,632 fish Killed 254,879 fish Killed 130 fish Unknown 258,641fish

[1]Number of incidents where manure was released into surface waters

Table 16. Summary of fish kill incidents tabulated by cause during the three-year period 1996-1998 (summarized by the Associated Press and updated by Lee Ganske, Minnesota PCA):

Manure 6	Winter kill 6	*Columnaris* bacteria 14	Thermal shock 7	Low flow oxygen 3
Milk spill 2	Parasites 1	Silage leachate 1	Shampoo spill 1	Ammonia 1
Chlorine 1	Sugar beet wastes 1	Unknown 17		

Summary of fish kills and livestock impacts to fishes

- A few large spills cause significant impact
- It is widely believed that there are many spills that go un-reported
- Minnesota does not have any coordinated system of tracking manure-related (or other) fish kill information
- Livestock impacts to game fish have been intensively studied, primarily in the western United States
- Most studies have concluded that grazing negatively impacted the fish population but based that conclusion on very weak or flawed experimental designs
- In only very few cases are there data describing impact to the overall fish community and those data are inconclusive
- Minnesota has not implemented a system for tracking fish kills (associated with livestock or other influences). At least two agencies have responsibility for responding to fish kills but fish kills are not regularly recorded and reported.

Influence of livestock on birds

Livestock has been widely reported to cause significant decreases in wildlife species and numbers (e.g., Ames, 1977; Townsend and Smith, 1977; Tubbs, 1980; Wiens and Dyer, 1975; Kauffman and Kreuger, 1984). However, in some cases other influences (e.g., either mammals or birds nest-predators) are more significant on hatching success than trampling by livestock or disturbance due to road use (Liker and Szekely, 1997). Therefore, as with fisheries and other aquatic resources, results are equivocal.

Lincoln's Sparrows (a small passerine which breeds in montane meadows) are potentially vulnerable to local extirpation because of their insular distribution, low population density, and fluctuating habitat conditions. Heavy damage from livestock grazing drastically increases the probabilty of local extirpation (Cicero, 1997). More than 20 years of relief from grazing had little influence on the habitat structure or bird species composition of a pinyon-juniper woodland. In general, habitat changes had been such that the bird community did not respond that quickly. Livestock grazing also indirectly affected the nesting success of some songbird species via the influence of grazing on cow bird abundance (Goguen and Matthews, 1998). Those nest parasites are a significant influence on songbirds in many habitats.

One possible link between livestock grazing and bird population declines in arid regions is variation in nest predation rates (Ammon and Stacey, 1997). In a study comparing a montane riparian community subdivided by a fence, one side of which traditionally has been summer-grazed, and the other side rested from grazing for 30 years Ammon and Stacey (1997) found that ground vegetation was more abundant, willows (Salix spp.) less abundant, and vertical vegetational diversity was lower on the grazed relative to the rested side. Predation rates on real nests were higher on the grazed side compared to the rested side. Predation on artificial nests in streamside willows that differed in abundance across the fence suffered greater predation rates on the grazed compared to the rested side. Livestock grazing may affect nesting for riparian birds by reducing streamside vegetation, increasing detectability of nests or through changes in predator assemblage.

Both the presence of waterbirds and their densities has been shown to increase in association with livestock in coastal areas. In many of these coastal (which may have some analogy to Minnesota lakeshoers), habitat has been reclaimed as pastureland. These open, exposed pasture landscapes offer valuable habitats to nonbreeding waterbirds. Colwell and Dodd (1995) suggest that grazing in coastal pastures can be used as an intentional management practice to provide a mosaic of vegetation heights. This resulting mosaic would yield greater waterbird diversity as well as higher densities of some species. In fact, Colwell and Dodd (1995) suggest that, although shorebird use did not correlate with use of pastures by cattle, grazing by livestock is probably the most effective means by which to achieve habitat characteristics attractive to shorebirds while maintaining compatible human uses on private lands. Several years earlier, Kaufman and Kreugher (1984) had concluded that when properly managed, grazed areas might even increase numbers of some bird species.

That pattern, as would be expected, appears to be true only for species which can take advantage of the more open landscape and its spatial distribution of food, predators and competitors. For example, the Redshank, a relatively rare British coastal bird does not excel under such conditions. Norris et al. (1998) conclude that their analysis of Redshank survey data, together with primary data they collected, suggest that heavy grazing is a significant threat to saltmarsh habitats and breeding Redshank, on a national scale.

On a more positive note, waterfowl probably respond positively to some levels of livestock use. Although spring grazing reduced nest densities of gadwall and blue-winged teal, nest density of gadwall increased after spring grazing was terminated. During the study, the amount of grass/ brush increased, whereas the amount of brush and brush/grass decreased on control and treatment fields (Kruse and Bowen, 1996). Although those authors measured habitat changes and nesting success, they did not comment on total or species specific waterfowl density nor on food availability. It is clear that habitat needs of a variety of species of wildlife that depend on grasslands need to be considered when deciding how to manage habitat (Kruse and Bowen, 1996). It also is clear that " habitat alone does not make a population nor a community" . The increased nutrient loads which enter the water from well managed grazing might not elicit a favorable response from the entire aquatic community, but might be expected to provide increased food resources for many waterfowl species.

Similarly, Paine et al (1996) suggest that for many grassland songbird species, pastures represent some of the best available breeding habitat in the Upper Midwest. There is increasing interest in intensive rotational grazing (IRG) among Midwestern livestock farmers, which may result in an expansion of pasture hectares in the region. Those authors tested 3 rotational grazing systems: a 1-day dairy rotation stocked at 24 head ac^{-1} a 4-day beef rotation at 6 head ac^{-1}, and a traditional, non-intensive 7-day rotation at 3 head ac^{-1}. Paddock size (0.5 ac) and nest density (15 nests $paddock^{-1}$ were held constant. Trampling damaged a mean of 75% ($\pm$ 3.1%) of the nests for all 3 treatments during 8 consecutive replications. While the 7-day treatment exhibited a pattern of greater nest trampling during cattle grazing periods than during rumination periods, this pattern was less evident in the 4-day treatment and absent in the 1-day treatment. Increasing vegetation height-density and percent vegetation cover were associated with reduced nest trampling fates, but pasture forage production and removal were not associated with nest damage (Paine et al., 1996).

Overall, several studies have shown that livestock has negative impacts on birds (c.f., Dambach and Good, 1940; Overmire, 1963; Owens and Myers, 1973; Reynolds and Trost, 1980; Smith, 1940; as well as the papers cited above). Many of these changes have been summarized by Fleischner (1994). However, in higher precipitation and higher productivity areas (perhaps like west-central Minnesota) grazing results in a more patchy landscape, increasing habitat diversity (Ryder, 1980). Many landscapes do recover from grazing abuses in a relatively short time. Duff (1979) found a 350% increase in songbird and raptor populations after an eight year release from grazing. Crouch (1982) found more ducks, more upland game birds, and twice as many terrestrial birds after seven year's release from grazing. However, grazed areas seem to offer had significantly more habitat for aquatic and shoreline birds (Cowell and Dodd, 1995). Mosconi and Hutto (1982) found significant increases in species composition and foraging guilds of birds in lightly grazed areas compared to heavily grazed. Kauffman (1982) and Kauffman et al. (1982) no significant impact on total avian density, but did find a differential use among species and guilds, in which grazed areas had more insectivores and un-grazed areas had more granivores. Thus, Kauffman and Kreuger (1984) conclude that grazing effects on birds are neither uniform nor clear.

The publications reviewed in this section indicate that:

- Livestock grazing often reduces canopy density and therefore habitat for riparian birds. That in turn reduces densities and diversity of some passerine species
- Some birds excel in the more fragmented riparian habitat that results from grazing and that same pattern is true for many species which rely on grassland habitats
- Shorebird populations (especially coastal species) appear to be positively impacted by low levels of grazing; it is not clear that the same responses would be shown in Minnesota waterbirds
- No evidence suggests that waterfowl are negatively impacted by livestock, although those waterfowl are dependent on aquatic invertebrates and may be secondarily impacted by changes in food availability.

Impacts of livestock on wildlife

Grazing can be a useful tool to enhance wildlife habitat (Holechek et al., 1982). However, grazing must be carefully managed to control the frequency, intensity and timing of livestock access to insure compatible use with wildlife. Improved livestock management will facilitate more streamside vegetation and increase the abundance and diversity of terrestrial habitat (Platts, 1991).

Livestock in arid regions often concentrate their grazing in riparian areas that may lead to degradation of native vegetation and effect wildlife populations. Hayward et al. (1997) found that small mammals at a desert wetland (cienaga) in southwestern New Mexico were 50% more abundant on 2 plots from which livestock were excluded over a 10-year period than on 2 similar grazed plots. Incorporating a few livestock exclosures of moderate size as an alternative management strategy could benefit a variety of species of wildlife in riparian areas (Hayward et al., 1997).

Mule deer home ranges, determined with radio collars, increased in area as cattle grazing level increased from ungrazed to heavily grazed in a montane forest and mountain meadow in the Sierra Nevada, California (Loft et al., 1993). Home ranges of cattle were larger with heavy grazing than with moderate grazing. Deer and cattle were attracted to the patchily distributed meadow-riparian and aspen habitats, but some deer exhibited temporal partitioning by avoiding such areas when cattle were present. In the absence of grazing, meadow-riparian habitat comprised a greater proportion of deer home ranges than during grazing, but during moderate and heavy grazing, a greater proportion of montane shrub habitat was included within deer home ranges, likely because cattle also preferred meadow-riparin and aspen habitat (Loft et al., 1991). Deer shifted habitat use by reducing their use of habitats preferred by cattle and increasing their use of habitats avoided by cattle. Deer also spent more time feeding and less time resting with increased cattle stocking rates (Kie et al., 1991). Deer increased their time spent feeding by shortening the length of resting bouts and including more feeding bouts each day, not by increasing the length of each foraging bout. Cattle were generally indifferent to the presence or absence of deer.

We did not find other evidence that livestock management significantly alters habitat or populations of large mammals. However, such a relationship seems self evident in many areas of the US where extensive lands have been deforested, fenced and converted to grazing. In those areas, habitat has changed, food resources have changed and predator-prey relationships have changed. Clearly, there are impacts of cattle on wolves in Minnesota and impacts of wolves on cattle. The extent and significance of that interaction and the wisdom of selected management alternatives is a very active area of debate and policy discussion. We have chosen to exclude those issues from this review because they are discussed elsewhere in a diverse and complex scientific and decision sciences literature.

With regard to small mammals and other wildlife, livestock impacts are seemingly species specific and perhaps site specific. When properly managed, grazed areas might increase

numbers of some mammal species (Kauffman and Kreugher, 1984). For example, Rosenstock (1996) reported that un-grazed patch and macrohabitat sites had more surface litter, greater perennial grass cover, and taller perennial grass plants, but treatment response varied among sites. Small mammal responses were apparent only at the macrohabitat scale, where un-grazed sites had 50% greater species richness and 80% higher abundance. Small mammal reproductive activity and biomass were not affected by rest from grazing at either scale. Duff (1979) did find a very large (350%) increase in small mammal populations after eight years of rest from grazing. That seemingly contradictory pattern is seen in greater depth in the summaries provided by Fleischner (1994).

These references on wildlife impacts show that:

- Overall, it is apparent that the literature is somewhat diverse and appears contradictory
- there are a variety of responses and some species clearly are provided an advantage under livestock-impacted conditions
- the specific nature of the site and the surrounding landscape will strongly influence wildlife responses
- there is a dearth of controlled, replicated experiments upon which to base these conclusions.

Endocrine disruption and other physiological impacts on fish and wildlife

There are increasing reports of hormone disruption and anomalous development in many species. That has been attributed to anthropogenic as well as certain naturally occurring substances. Increased susceptibility to disease pathogens is frequently reported. In some cases, that is seen as anomalous development of sexual behavior or function. This process and its effects in mammals was extensively reviewed by Elliott (1998). Many scientists are suggesting that endocrine disruption from exposure to a wide range of chemicals is the generic cause of these anomalies (Davis and Foushee, 1996). At least two papers have reported estrogens in runoff on lands that were intensively grazed (Shore et al., 1995; Nichols et al., 1997). However, attributing impacts to " endocrine disruption" or the presence of a hormone is more symptomatic than causal. We have made very little progress to date in understanding specific cause-effect relationships between landscape management practices and responses in the endocrine system of various animals.

The problem has received very high level attention. For example, recently the Executive Office of the President (Executive Office, 1998) summarized the problem and issued a call for research. That paper reported that the largest endocrine disruption research efforts are in human health, which is clearly dominant over ecological and exposure research. However, endocrine disruption ecological research and studies in immunotoxicity are very limited. It is clear that on-going research addresses only a few species and a limited number of compounds. There is a dearth of either observational or experimental field data; most studies are laboratory mammals although there are several fish studies which rely on field observations (see below).

These compounds are important because they are capable of altering hormone pathways

that regulate reproductive processes. In general, the ecological implications of that disruption has not been recognized. One limitation in improving that recognition has been development of techniques to predict and more accurately assess the ecological relevance of exposure to endocrine-disrupting compounds (Arcand-Hoy and Benson, 1998). A workshop was held recently among 30 international scientists from a wide variety of disciplines to assess the status of those methods. That group reached consensus that mammalian test methods generally are suitable for assessing a variety of potential effects in mammalian wildlife. However, it was not clear from their discussions that those tools would serve adequately for other classes of vertebrate wildlife. There are tests useful for bird and fish species but they are not suitable for routine screening. The group concluded that too little is known at present about the biological role of estrogens and androgens in reproduction and development of invertebrate species to recommend any specific assays (Ankley et al., 1998).

In the few cases where cause and effect have been demonstrated (e.g., alligators, Bald Eagles; Arcand-Hoy and Benson, 1998; Crain, 1998) anthropogenic chemicals such as PCBs and common herbicides have been shown to be the cause. Some authors have hypothesized that similar permanent, organizational changes occur in a variety of wild reptiles exposed to endocrine-disrupting contaminants (Crain and Guillette, 1998). In Lakes Apopka and Okeechobee, for example, alligators exposed to atrazine had significant sexual dysfunction (Crane, 1998).

Those impacts have been duplicated experimentally in common carp (*Cyprinus carpio*). Gimeno et al. (1998) exposed carp for 3-months to sublethal concentrations of two compounds (4-tert-pentylphenol, TPP and 17 beta -estradiol, E2). After exposure, the testes showed progressive disappearance of spermatozoa and spermatogenic cysts, and a higher incidence of pathological alterations with time at all TPP and E2 concentrations (e.g. fibrosis, vacuolation and atrophy of the germinal epithelium). Those fish exposed to the highest E2 concentration did not produce any milt. Goodbred et al. (1996) conducted a field study seeking the same kinds of occurrences. They examined a series of biomarkers in common carp. They did not find a significant regional difference in steroid hormones detected for males, but females from the Northern and Southern Midcontinent (including the Upper Midwest) were significantly different from other regions of the country in one or both hormones. Contaminants that had significant (a=0.05) correlations with biomarkers were organochlorine pesticides, phenols and dissolved pesticides. There was evidence that fish in some streams are be experiencing endocrine disruption. Because their data were highly variable, they conclude that future studies should shift to more intensive study of fewer sites, including reference and contaminated sites (Goodbred et al., 1996).

Matthiessen and Gibbs (1998) studied Tributyltin (TBT), a common industrial chemical. They suggest that there is " abundant and undisputed field data" that link TBT to a variety of effects in snails. The principal phenomenon observed is disruption of the sexual development of the animals. This may result in reduced breeding success and (in its final implication) population disappearance. They conclude that TBT-induced masculinization in gastropods, imposex and intersex, is the clearest example of endocrine disruption described in invertebrates to date that is

unequivocally linked to a specific environmental pollutant.

The specific causes of such endocrine disruption are not clear. Laboratory bioassays are successful in identifying certain mechanisms abut often conclude that there are multiple mechanisms involved (e.g., in trout, as studied by Tremblay and Van Der Kraak, 1998). That Amultiple cause@ conclusion is to be expected because we put a large variety of compounds into the environment, where they interact with each other. Results are always complex. For example, Montagnani et al. (1996) presented results of a study on the overall oestrogenic potential of sewage effluent being discharged into a river. They found high levels of oestrogenic potential in the effluent and also in stream water upstream from any sewage-treatment works so it was difficult to attribute any change to the effluent itself. We know that many insecticides, herbicides and fungicides exhibit weak endocrine activity, based on various laboratory assays (Sumpter and Sohoni, 1998).

These issues are of concern in a Livestock GEIS because a) these impacts are often attributable to agricultural if not livestock practices and b) we know so very little about cause and effect. Hampson et al. (1995) commented that many endocrine disruptions have been shown to be due to agricultural chemicals, and then they documented the relative contribution of a variety of chemical inputs to provide context. For example, they state that approximately 1% of all applied pesticides enter surface water. In Ontario, approximately 13 tons of pesticides of concern could enter surface water and eventually reach the Great Lakes. This is higher than the estimated 8.5 tons of cadmium, mercury, and PAHs coming from municipal and industrial point sources in Ontario. Matthiessen (1998) concludes that the real and potential effects of those chemicals on fish and molluscs is so significant that action is appropriate. He states that, while more research is required to make firm predictions of the population-level consequences of endocrine disruption, and to develop effective hazard identification tests for these substances, it would be prudent to begin making voluntary regulatory controls where possible in view of their undoubted potential for environmental damage.

From these references we can conclude that:

- Endocrine disruption is a poorly understood science today
- We have no evidence that livestock management causes endocrine disruption in any fish or wildlife species
- The changes caused by livestock are consistent with those known to cause endocrine disruption
- Clearly, any regulation that attempts to regulate the suite of "potential endocrine disrupting chemicals" will be of interest and concern to the people and agencies concerned with decision making based on a livestock GEIS.

Conclusions

- Vegetation responses to livestock management are highly site specific, primarily because ecosystems are highly variable in space and time (Larsen et al., 1998).
- Livestock damage in small to medium sized, relatively stable streams leads to widening of the channel but not necessarily to significant decreases in overall fish habitat (Williams et al., 1992).
- Several authors have concluded that a significant amount of caution is needed in making even coarse inferences from one area to another (Williamson et al., 1992) and that management practices must be stream-specific (Meyers and Swanson, 1991).
- Several studies have shown negative impacts of livestock on birds (Dambach and Good, 1940; Overmire, 1963; Owens and Myers, 1973; Reynolds and Trost, 1980; Smith, 1940). However those effects are not uniform among locations or times (Kauffman and Kreuger, 1984).
- Small mammal responses are usually apparent only at relatively site specific scales (Rosenstock, 1996).
- It is clear that we have limited information upon which to judge the applicability of those literature results to local conditions or to generalize or predict real and potential impacts of livestock management in the Upper Midwest.

4. Human Health Risks from Water Polluted by Animal Agriculture

The question of what potential human health effects may result from animal agriculture, via water, is difficult to answer because it involves a complex set of factors. There are basically two types of risks in drinking water which are related to animal agriculture: excessive nitrate levels and pathogens. Much of our knowledge about these two has been gained over the past fifty years, especially during the past two decades. However, as more information has become available, more questions have been raised, many of which are difficult to study or assess.

Nitrate is a common contaminant found in many wells in Minnesota. It has been known since the mid-1940s that too much nitrate in drinking water can cause serious health problems for infants. Some researchers have even suggested that nitrate may also play a role in the development of some cancers. However, several studies involving nitrate and cancer over the past two decades have ended with ambiguous results. Therefore, we must conclude at this time that, to the best of our knowledge, there is no clear evidence that nitrate ingestion results in an increased cancer risk. Obviously, more work needs to be done to provide a definitive answer to whether there is any relationship of nitrate to cancer.

A pathogen is an organism which causes disease in a susceptible host. Knowledge about potential human pathogens has grown at an exponential rate. In addition, the explosion of new technological breakthroughs has allowed chemical and biological constituents to be detected at several orders of magnitude lower concentration in water (albeit with variable levels of precision, depending on the parameter being sought) than was possible only a few years ago.

The relevant fields of science bearing upon this question have broadened in the last two decades, as it has become obvious that numerous areas of expertise must be successfully integrated into a cohesive understanding. Such fields of study range from the laboratory-based sciences, including microbiology, animal health and veterinary medicine, chemistry, and (human) medical pathology; human health risk management; field-based sciences of geology, soils, hydrogeology, climatology, ecology, and animal and crop husbandry; and waste treatment and waste disposal technology.

Another important complexity in answering this question lies in the rapid rates of change in some of the pathogens: drug-resistance has induced significant selective changes in the pathogen populations. At the same time, new strains, types, and groups of pathogens are being identified on a regular basis.

One of the most important factors may be the changes within the human population itself. It has been estimated that by the year 2010 (barely a decade from now) approximately 20% of the human population will be classified as particularly "vulnerable" to health effects of pathogens and chemical pollutants. "Vulnerable" segments of the population will include infants and the elderly, and all those people whose immune systems are compromised. The latter group includes persons undergoing cancer therapy; organ transplant patients (who must remain on anti-

rejection medications); as well as those who have the human immunodeficiency virus (HIV), which causes AIDS (acquired immunodeficiency syndrome). This is a serious and sobering prediction. It means that one in every five persons will be particularly vulnerable; that at least one person in most families will have a particular vulnerability to potential health hazards.

Everyone needs clean drinking water to survive. This projection on vulnerable populations requires that old assumptions about clean water cannot be summarily overlooked. Consideration of public health demands that "acceptable" levels of water quality can no longer be defined by a negligible risk to a healthy adult. This and other assumptions will need to be re-evaluated. The new standard will need to consider risk levels in vulnerable populations. This new standard will be part of the challenge in answering the question of what human health effects may be caused by animal agriculture, via water.

Pathogens in Animal manure:

The utilization of animal manure on agricultural land used for raising crops and grazing animals is a low-cost means of manure disposal and soil amendment. However, animal manure may contain a variety of microorganisms which may be pathogenic to humans and/or animals. The major types of pathogens include: bacteria, viruses, parasite eggs, protozoa, and fungi. Indeed, pathogenic bacteria and viruses have been isolated from feedlot wastes (Hrubant, 1973; Derbyshire et al. 1966). The application of manure on pastures and/or fodder crops may, therefore, result in: groundwater contamination, internal and/or external contamination of crops, translocation of pathogens to grazing animals, surface water contamination via run-off, and generation of contaminated aerosols (Table 17).

Table 17. Potential pathways of pathogen transmission

1. Contamination of surface drinking water supplies.
2. Contamination of ground water supplies.
3. Direct contact with contaminated environment e.g., recreational use of water.
4. Transmission by inhalation of contaminated aerosols.
5. Contact with contaminated surfaces.
6. Transmission via contaminated vegetables to homes and hospitals.
7. Transmission from contaminated environments via insects.
8. Concentration of pathogens by shellfish.

Risk to animals:

1. Transmission to farm animals having contact with contaminated surface waters.
2. Transmission to farm animals having contact with contaminated grazing land.
3. Transmission by direct inhalation of contaminated aerosols.
4. Transmission from polluted surface waters via wild birds.
5. Transmission from contaminated environments via insects.

Contamination of surface water may pose a problem when these resources are used as a source of recreational or drinking water. The potential of disease transmission to humans and animals from land application of animal manure will depend upon: (a) the microbiological quality of manure, which in turn depends upon the type of treatment it has received; (b) the survival of pathogens for a sufficient period of time and in sufficient numbers; and (c) the significance of this route of transmission as compared to other potential infection routes (Table 18).

Table 18. Factors affecting transmission and pathogenicity

1. Minimum infective $dose_{50}$.
2. Number of pathogens present in manure.
3. Frequency and seasonality of pathogen occurrence in manure.
4. The effect of manure treatment, if any, on number of pathogens present.
5. Survival of pathogens in the environment.
6. Removal of pathogens by soil following land application of manure.
7. Significance of this route v/s others in pathogen transmission.
8. Host susceptibility.

During the past 30 years, there have been major changes in livestock production practices including intensification, which has generated large quantities of manure by individual feedlot enterprises. Under conditions of confinement housing in which little or no bedding is used, composting is not workable, and the manure has to be handled in semi-solid or liquid form. Sometimes this is spread on land as a daily operation but, more frequently, liquid manure is stored in underground or above ground tanks for days to months before it is spread on land. The material may then be transported and spread by spray; from tankers or by pumping through an irrigation system. It has been estimated that the farm livestock in the U.S. produce at least 10 times the amount of biological wastes produced by the human population (Heald and Loehr 1971). For example, 1000 pigs excrete 2-3 tons of feces/day which if mixed with urine and litter, amount to 6 tons of manure/day (Wray et al.,1975).

Pathogens that may be present in animal manure:

Animal manure may contain bacteria, viruses, and protozoa which may cause disease in humans and/or animals. Table 19 shows some of the pathogens that may be present in manure. It should be recognized that this list of pathogens is not static; new pathogens are constantly being recognized and the significance of the old ones changes because of advances in analytical techniques and changes in animal agriculture. Microorganisms are also subject to change because of mutation and adaptation. Diseases that are common to humans and animals are called zoonoses. Zoonotic agents are described as the ones that are naturally transmitted between humans and vertebrate animals. Table 20 shows the relative risks of bacterial diseases that can be transmitted between humans and animal via water.

Table 19. Pathogens that may be present in animal manure

Pathogen Name	Disease Name	Symptoms in Humans
Salmonella sp.	Salmonellosis	Fever and gastrointestinal disorders
Escherichia coli		Nausea, dehydration, and bloody diarrhea, particularly in infants Particularly severe form, sometimes fatal
Leptospira interrogans	Leptospirosis (Weil's disease)	Fever, headache, chills, rash; hemorrhagic infections of the kidney, liver, and nervous systems; rarely, fatal
Listeria monocytogenes	Listeriosis	Fever, muscle aches; nausea, diarrhea; convulsions; stillbirth
Campylobacter jejuni	Campylobacteriosis	Diarrhea, nausea, abdominal pain, fever
Histoplasma capsulatum	Histoplasmosis	Fever, respiratory symptoms, chest pain, dry cough. Chronic pulmonary disease can be fatal.
Cryptosporidium parvum	Cryptosporidiosis	Watery diarrhea, stomach cramps. Sometimes fatal.
Giardia lamblia	Giardiosis	Diarrhea, abdominal cramps, nausea
Viruses such as adenovirus, enteroviruses, reoviruses, and rotaviruses	Viral infections	Fever, hepatitis, paralysis, headache, nausea, rash, meningitis, epidemic vomiting, eye infections, or respiratory infections depending on the virus involved

(a) Bacteria: Bacteria that are pathogenic to humans and/or animals may also be present in animal manure and may survive for some period of time in the environment. Treatment and/or storage of manure will result in degradation of bacteria. Thus, the microbiological quality of manure depends upon the amount of time it has been stored and if it has received any treatment. The pathogenic bacteria may enter a new host by ingestion or inhalation. The major symptom caused by most of these bacteria is diarrhea but they may also cause generalized or localized infections (Table 20). Salmonella is an enteric bacterium that is of concern to both humans and animals. Enterotoxigenic, enteroinvasive, and enteropathogenic strains of E. coli can also be

pathogenic and have been found in the water environment. Even the non-pathogenic serotypes of E. coli may be of concern because of their ability to drug resistance to other enterobacteria. As a recently recognized cause of diarrhea, Campylobacter is now believed to be of major concern throughout the world. It now seems that Campylobacter is the single most common bacterial cause of diarrhea in several countries. Infection with Campylobacter jejuni may result in asymptomatic infection, mild symptoms or severe disease. Wastes from dairies and abattoirs that handle tuberculous animals, will almost certainly contain M. tuberculosis. Farm animals grazing on contaminated pastures may become infected.

Table 20. Relative risks of bacterial transmission between humans and animals via water.

Bacteria	Disease	Level of risk
		—
Clostridium tetani	Tetanus	Low Risk
Brucella melitensis	Brucellosis	Low Risk
Bacillus antracis	Anthrax	Low Risk
Erysipelas rhusiopathiae	Erysipelosis	Low Risk
Leptospira spp.	Leptospirosis	Medium Risk
Yersinia enterocolitica	Yersiniosis	High Risk
Salmonella spp.	Salmonellosis	High Risk
Mycobacterium tuberculosis	Tuberculosis	High Risk
Atypical mycobacteria	Mycobacterial infections	High Risk
Escherichia coli	Colibacillosis	High Risk
Campylobacter jejuni	Campylobacteriosis	High Risk
Listeria monocytogenes	Listeriosis	High Risk

(b) Drug resistant bacteria: The use of antibiotics in animal agriculture is considered to be a potential threat to human health because of the generation of drug resistant bacteria. The antibiotics do not in themselves cause resistance among bacterial populations, rather they select resistant clones which are already present in the flora. The presence of drug resistance in bacterial pathogens is of concern but drug resistant non-pathogenic bacteria are also important because they can transfer their resistance to pathogenic bacteria by conjugation. The incidence of antibiotic resistance among E. coli isolates from man and animals can vary with the population surveyed. Thus, their prevalence is greater in intensively reared calves, pigs and poultry but less in grazing cattle and sheep because the latter have little or no exposure to antibiotics. Also, the incidence of drug-resistant coliforms is higher in children than in adults, and is higher among adults from rural areas (who have contact with animals) than among adults living in towns (Linton et al., 1972). The handling of animal carcasses can also result in the establishment of

drug-resistant E. coli of animal origin in humans (Hinton, 1986).

The drug resistant strains of E. coli readily colonize the intestinal tracts of young animals and may persist in the fecal flora of humans and pigs even without antibiotic selection pressure (Hinton, 1986). E. coli isolates from calves tend to be more resistant to antibiotics than those from adult cows (Hinton, 1986). It has been suggested that the multiply resistant E. coli strains which colonize calves during the first week of life, are probably derived from the farm environment and are selected by the use of antibiotics in calves which had been reared on the premises during previous years. The overall level of drug persistance in E. coli remained unchanged during seven weeks of slurry storage and E. coli was found to survive for at least 15 months in a slurry tank (Hinton and Linton, 1982). Tetracycline resistance is relatively common in E. coli isolates from pigs. E. coli isolates from chickens are usually resistant to streptomycin, sulphonamides, and tetracycline. In one study, the medical, rather than the veterinary, use of tetracyclines was found to be responsible for the relatively high incidence of tetracycline resistant E. coli isolates from man (Richmond and Linton, 1980).

(c) Viruses: More than 110 different types of human enteric viruses can be excreted in human feces and may be found in raw municipal sewage. Although the number of viruses in sewage is reduced upon sewage treatment, they are not completely eliminated. The viruses get further diluted when treated sewage is discharged in surface waters. Although they can not multiply in the environment, they can survive for much longer periods than bacteria. The use of treated sewage as soil amendment can also result in surface water pollution because of run-off. It is important, therefore, to detect the presence of viruses in water and soil to determine the safety of their usage. However, it is difficult to detect the presence of these viruses in surface waters by conventional methods unless a large quantity of water is first concentrated in to a small volume that can be conveniently assayed for viruses. We have developed techniques for the concentration and detection of human enteric viruses from large volumes of water, wastewater, soil and sludges (Gerba and Goyal, 1982). Similar techniques for the concentration and detection of animal enteric viruses do not exist and hence there are no data on the virological quality of raw animal manure, treated manure, water, soil, fodder, etc.

Human enteric viruses have been found to gain access to groundwaters during land application of wastewater. Climatic conditions, soil type and possibly management practices of soil flooding appear to be some of the factors controlling virus migration through soil. Previous studies have indicated that adsorption of viruses to the soil matrix plays a major role in virus retention as sewage-laden waters percolate through the soil (Gerba et al., 1975). Thus, factors influencing adsorption phenomena will determine not only the efficiency of virus removal during percolation of wastewater through soil but their long-term behavior. Among the factors known to influence virus adsorption to surfaces are pH, salt concentration, the nature of the adsorbent, type of virus, and time and flow rate (Gerba et al., 1975). It is also known that elution of viruses from surfaces is possible under appropriate environmental conditions (Gerba et al., 1975)

Previous studies indicate that certain management practices may be useful in controlling the migration of viruses into groundwater during the land application of wastewater (Lance et al.,

1976). Utilizing 98-in columns of sandy loam soil, these authors found that migration of viruses after a rainfall could be minimized if the soil was re-flooded with sewage shortly after the rain. Few studies exist on the survival of enteric viruses in soils (Bagdasar'yan, 1964; Lefler and Kott, 1974; Hoadley and Goyal, 1976). These studies were largely concerned with virus survival near the soil surface and were limited in scope in that they involved the study of only a few viruses and soil types. These studies need to be expanded to include several animal and bacterial viruses under a variety of environmental conditions which would more closely approximate those found in the subsurface environment.

(d) Protozoa: Giardia and Cryptosporidia are considered to be the two most important waterborne protozoa. A large outbreak of waterborne outbreak of Cryptosporidia occurred in Milwaukee, Misconsin in 1993. More than 400,000 people were affected in that outbreak. These protozoa are significant because they can not be inactivated by the commonly used disinfection procedure. To remove these pathogens, one has to resort to water filtration.

Risk to humans from water pollution by animals:

Some incidents of human disease attributable to contact with livestock waste have been reported. Stanley et al. (1998) isolated Campylobacter jejuni from groundwater in the Arnside area of Cambria. Some of the strains isolated were of the same biotype as the ones from a dairy farm situated within the hydrological catchment of the polluted spring indicating that the groundwater was a vehicle for bacterial transmission. In a study of a farmworker community in Zimbabwe, Campylobacter spp. were common in chicken faeces but not in houseflies or household stored drinking water (Simango and Rukure, 1991) indicating that chickens were the main potential source of Campylobacter in the homes of farmworkers.

In a longitudinal study of four dairy farms, it was suggested that E. coli O157:H7 was disseminated from a common source on these farms and that this strain could persist in the herd for up to 2 years (Shere et al., 1998). In a Russian study, Gordeiko and Pushkareva (1990) detected Yersinia in 25.4% of water samples taken from wells situated in the zone of irrigation with sewage water from a swine-breeding complex. Conversely, no Yersinia was isolated from wells that were remote from the irrigation zone. They also established an epidemiological relationship between a case of Yersinia infection and the use of infected well water.

Prokopcakova and Pospisil (1984) conducted serological surveys for leptospirosis in rodents, cattle and humans in the vicinity of two large water reservoirs in Eastern Slovakia. Sera from 243 rodents, 168 cattle, and 876 humans were examined; 8.2%, 7.7%, and 3.2%, respectively were positive. The presence of antibodies to the same Leptospira serovar in humans, cattle and rodents indicated the existence of close contact among humans and animals with the possibility of acquiring water-borne infection in recreation zones. An epidemic of hemorrhagic fever caused by Leptospira was reported in rural Nicaragua following heavy flooding. A case-control study revealed that the illness was associated with walking in creeks, having household rodents, or owning dogs with titers of $\geq$1:400 to Leptospira. Leptospira spp. were isolated from case-patients and from potential animal reservoirs. Most likely, this epidemic

resulted from exposure to flood waters contaminated with urine from infected animals, particularly dogs.

Five boys from a small town in rural Illinois developed leptospirosis after swimming in a small pond. Leptospira interrogans serovar grippotyphosa was isolated from urine of 2 cases and from pond water. A high seroprevalence for L. grippotyphosa was also found in animals near the pond indirectly suggesting the transmission of the organism from area animals to humans.

Rhodococcus coprophilus and associated actinomycetes were isolated consistently from feces of farm animals, poultry reared in proximity to farm animals and wastewater polluted with animal fecal wastes but not from samples of human feces. The fecal coliform to fecal streptococci ratio could not distinguish between human and animal fecal samples but R. coprophilus to Actinomyces ratio could (Mara and Oragui, 1981). Introduction of organic farming practices on a farm in south-west England was responsible for the introduction of environmental mycobacteria on that farm. The change in the profile of environmental mycobacteria has important implications for the immunological priming of humans and animals (Donoghue et al., 1997).

A marked peak in human cases of cryptosporidiosis was noticed in the Sheffield area in 1986. Epidemiological investigations suggested a waterborne outbreak of cryptosporidiosis, the possible source of which was cattle on a farm adjacent to the reservoir complex (Rush et al., 1990). In another study, 249 surface water samples were tested for parasites in 2 adjacent British Columbia, Canada, watersheds: the Black Mountain Irrigation District (BMID) and the Vernon Irrigation District (VID) both of which serve rural agricultural communities active in cattle ranching. Giardia cysts were not detected in the raw water samples collected from lake sources at the headwaters of both watersheds but were found in 100% and 97% of water samples at BMID and VID intakes, respectively. Significantly higher levels ($P < 0.05$) of Giardia cysts were found at the BMID intake than at the VID intake probably because cattle have access to creeks in the BMID watershed, whereas access is restricted in the VID watershed. Peak concentrations of both parasites coincided with calving activity. Fecal samples from cattle were positive in both watersheds: 10% in the BMID and 50% in the VID watersheds. No fecal sample was positive for Cryptosporidium. Thus, the differences in patterns of parasite contamination and cattle management practices may contribute to the unique watershed characteristics although they may be topographically similar and geographically adjacent (Ong et al., 1996).

Bates et al (1994) isolated vancomycin-resistant Enterococcus faecium (VRE) from raw sewage, farm animals and uncooked chickens. Two ribotyping patterns were found among isolates from animals and sewage and those from clinical sources. A blood and a urine isolate from separate hospital patients and porcine isolates shared the same ribotyping pattern and a stool isolate from a patient in the community and sewage isolates shared another pattern. This led them to suggest that animals might serve as a reservoir of VRE. We would like to suggest that humans may also serve as the source of organisms for animals.

Derbyshire and Brown (1978) isolated 10 porcine enteroviruses, 2 porcine adenoviruses and 1 coronavirus from 32 samples of pig slurry. Concentration of the same samples by

adsorption with polyelectrolyte yielded more viruses. No virus was isolated from 12 samples of slurry from dairy cows nor from 6 slurry samples from a calf-rearing unit. A porcine enterovirus was isolated from soil samples, collected 1, 2 and 8 days after pig slurry was spread on hay stubble. Two porcine enteroviruses were isolated from surface run-off from land on which pig slurry was routinely spread. However, none of the 36 samples of ground water were positive.

Even during the slaughtering process, Aeromonas has been found to spread from the intestinal contents of chicken carcasses to processing water to chicken carcasses (Akan et al., 1998). Eighty samples of wastewater from four slaugherhouses were examined. The slaughtering of pigs contributed more to contamination of wastewater with Salmonella than did the slaughtering of cattle. The cleaning and scraping of the gut also increased the bacterial load of wastewaters (de Zutter and van Hoof, 1980).

Studies showing negligible effect of animal manure on human health:

During routine examination of bathing areas near North Sea in Germany, Salmonella contamination was detected for the first time in 1988. To define the source of contamination, strains isolated from seawater and rivers were studied by molecular marker methods. The plasmid profile and antibiotic resistance patterns excluded the surrounding cattle industry as a source (Graeber et al., 1995). The presence of Salmonella in North Sea coastal water did not correlate with the presence of fecal indicator bacteria (Tobias and Heinemeyer, 1994). Also, Salmonella from agricultural sources proved to be irrelevant in this study.

Jones et al. (1980) examined 882 samples of settled sewage, sewage sludges and final effluents from eight sewage treatment plants. Of these samples, 68% were positive for Salmonella. Isolation frequencies from settled sewage, raw sludge, and anaerobically digested sludge were 85%, 87%, and 96%, respectively. Fewer isolations were made from final effluent (24%) and processed sludges (58%). Samples usually contained less than 200 salmonellae/100 mL. They argued that such low concentrations should not lead to disease in animals if suitable grazing restrictions are followed.

Smeltzer *et al.* (1979) spread cattle manure on experimental plots at the rate of 54 tons/ac/yr. The manure was applied to 2 plots at 6-monthly intervals while a further 2 plots received monthly applications. Samples of manure soil, run-off and groundwaters were examined for bacteria. Comparison of the bacterial counts from samples from the test plots to those of the control plots showed that no change occurred in the levels of coliforms or faecal coliforms over the 3 years of manure application. One hundred and fifty-seven isolations of Salmonella were made from the soil and water samples, but only 51 could be attributed to manure. No difference was observed in the effects of different application frequencies.

Escherichia coli serotype O157:H7 has become a major foodborne pathogen for the young and the elderly. The association of non-bovine products with outbreaks suggests that other vehicles of transmission may exist for this pathogen (Feng, 1995). Remote, supposedly pristine water samples have been found to be contaminated with Giardia cysts in the Yukon (Roach et al.,

1993).

Risk to food animals from the use of municipal sludge in agriculture:

It is a common practice to "blame" animal agriculture if a zoonotic agent is found to be the cause of an outbreak. It should be noted, however, that human sewage/sludge can and have served as a source of pathogens to animals. High levels of Salmonellae can be found in sludge and they can survive for weeks in sludge, grassland, and stored grass (Hess and Breer, 1975; Hess *et al.*, 1974). A study of 26,646 cattle in Switzerland between 1969 and 1978 revealed an increased isolation rate from cattle at times of year at which sludge was applied. Studies of carrier rates and serotypes in cattle grazing on sludge-treated pastures also indicated a positive association between the two and a cycle of infection (man-sludge-animal-man) emerged. Based on these studies, the Swiss authorities now treat sludge by pasteurization and anaerobic digestion before applying it on land (Breer et al., 1983).

In the Netherlands, several investigations have revealed that animal meat is the most important source of Salmonella infection in man and that a relatively high number of clinically health food animals, including poultry, are carriers (Edel et al., 1973, 1977, 1978). These studies have also demonstrated the existence of complex cycles of transmission which involve feedstuff, meat, patients, healthy carriers, sewage effluent, surface water, insects, birds, rodents, and food animals (Edel et al., 1973).

Several well-documented cases exist in which salmonellosis in cattle was caused by contamination of pasture with crude sewage or septic tank wastes (Anon, 1977). The risk to grazing animals from the spread of sludge on pastures will depend upon: the density of human population, the incidence of human salmonellosis, the extent of sewage and sludge treatment, agricultural practices, stocking density of animals, and weather. The presence of pathogens in sewage sludge will contribute to overall environmental contamination. However, this is not the only source of bacteria. It is important, therefore, to assess the contribution of bacteria to the environment from other sources as well as it is important to ascertain the background levels of bacteria before sludge application. Sludge spreading may increase the carrier rate in cattle and pigs which may pose a threat to humans through the contamination of meat, milk, dairy products, and working surfaces in kitchen.

Taylor and Burrows (1971) reported infection in calves that grazed on pastures to which a slurry containing 10^6 Salmonella dublin/mL had been applied a day previously. In a later study, 10^5 S. dublin/ml failed to infect calves when allowed to graze 7 days after spreading slurry (Taylor, 1973). Ayanwale et al. (1980) found that goats raised on corn silage grown on sludge-amended land did not become infected with Salmonella even though Salmonella was present in sludge.

Dorn et al. (1985) conducted a 3-year prospective epidemiologic study on 47 farms in Ohio receiving annual applications of 0.9-4.5 dry tons of treated sludge per acre. A total of 164 persons (78 families) participated. As a control, 46 farms were studied that did not use sludge.

From these control farms, 130 persons (53 families) participated. No significant difference was found in disease occurrence in man or domestic animals on sludge farm or control farm. This was attributed to the use of low sludge application rates that were in accordance with Ohio and the U.S. Environmental Protection Agency guidelines. These authors cautioned against using these data to predict health risks associated with sludges containing higher levels of pathogens and with higher sludge application rates and large acreages treated per farm than used in this study.

Survival of pathogens in the environment:

The microorganisms in animal manure are inactivated after exposure to the environment but they may survive for long enough period to be of public health and/or human health concern (Table 21). The native microflora in water and soil may sometimes inhibit pathogens. For example, when enterococcal isolates from dung water of 25 cattle farms in northeastern Slovakia were screened for bacteriocin production, Enterococcus faecalis V24 strain was found to produce a heat stable, largely hydrophobic bacteriocin with a strong inhibitory effect against Gram-negative bacteria (Laukova et al., 1998a, 1998b). The average total count of enterococci was $5x10^3$ CFU/mL. Enterococcus faecium was the predominant species (25%) followed by Ent. casseliflavus (19.2%), Ent. faecalis (9.6%), Ent. avium (1.9%), and Ent. durans (1.9%).

Table 21. Survival times of excreted pathogens in soil at 68-86°F

Pathogen	Survival Time (days)
Viruses	
Enteroviruses[a]	<100 but usually <20
Bacteria	
Fecal coliforms	<70 but usually <20
Salmonella spp.	<70 but usually <20
Vibrio cholerae	<20 but usually <10
Protozoa	
Entamoeba histolytica cysts	<20 but usually <10
Helminths	
Ascaris lumbricoides eggs	Many months

[a] Includes polio-, echo-, and coxsackieviruses.

Storage of animal slurry will reduce the number of pathogens present over time. Swine manure, for example, is stored in a pit at one end of the building, or in an outdoor lagoon, or in an underground tank. After 3 weeks of storage, Listeria monocytogenes could be detected in only one of the initially nine positive faeces samples. Two months after inoculation of stored liquid pig manure, stored liquid cattle manure and soil with L. monocytogenes, this bacterium

could not be traced in any of these materials. Radishes (Raphanus sativus) and carrots (Daucus carota), sown in soil inoculated with L. monocytogenes, were gathered after 3 months and examined for the presence of L. monocytogenes. Three of six radish samples were found to be positive. Remarkably, however, all carrot samples (six) were free of L. monocytogenes (Van Renterghem et al., 1991).

In Germany, Salmonella was detected in 50% and 36% of samples of biowaste and fresh compost, respectively. The seepage water from these sources was found out to be a reservoir of Salmonella; Salmonella enteritidis survived in seepage water for 42 days at 5°C (Knop et al., 1996). In lake water, Campylobacter jejuni survived longer than C. coli both at 4°C and 20°C (Korhonen et al., 1991). Both species survived better in filtered than in untreated water suggesting that predation and competition for nutrients may affect the survival of bacteria in the aquatic environment. Salmonella were found in the environment of a dairy two years after the occurrence of a clinical outbreak of salmonellosis. Samples of recycled flush water were positive for Salmonella indicating that hardy organisms can become established in the environment of modern free-stall dairies that use recycled water in their manure flush systems (Gay and Hunsaker, 1993). Similar results were noted in another study in which Escherichia coli K-12 survived for at least 28 days in sterile water but declined from $3x10^6$ to <10 cells per mL in 147 hrs in non-sterile water (Bogosian et al., 1992).

Olsen (1995) determined the survival of Serpulina hyodysenteriae in a lagoon that received effluent from a confinement building housing swine dysentery-infected swine. The organism could be isolated from lagoon water 5-6 days after the removal of shedder swine from the building indicating that the facility should remain idle for more than 5 to 6 days before repopulating with unexposed swine. In a study to identify possible environmental sources of infection on Etosha National Park, Namibia, Lindeque and Turnbull (1994) detected Bacillus anthracis in water and soil samples collected from sites not associated with known cases of anthrax. However, higher rates were found in water from waterholes in the western part of the Park at the time of an outbreak in elephants. They also found that the viability of bacilli in soil and water was limited. Porcine reproductive and respiratory virus (PRRSV) was shown to survive for 9-11 days in city and well water indicating that contaminated water may serve as source of this virus for other animals (Pirtle and Beran, 1996).

Treatment of slurry to reduce pathogen levels:

Attachment to particles influences not only sedimentation of (oo)cysts in surface water but also their behavior in drinking water treatment processes. Thus, the sedimentation velocity of Cryptosporidium parvum oocysts and Giardia lamblia cysts attached to secondary effluent particles increased with particle size whereas the sedimentation velocities of freely suspended (oo)cysts was too low to cause significant sedimentation in surface water or reservoirs (Medema et al., 1998).

Indicator bacteria as surrogates for pathogens:

Coliform bacteria have been used for more than 80 years as water quality indicators. Fecal

coliforms have been particularly useful in indicating fecal pollution of water sources. In one study, the source of Campylobacter jejuni in groundwater was traced to a dairy farm. However, the organism was not isolated in the absence of fecal indicator bacteria (Stanley et al., 1998). Unfortunately, these indicators are not infallible. Thus, de Souza et al. (1992) tested water samples from 113 drinking water places located on 60 different farms in Botucatu County, S. Paulo, Brazil and found 15% to be positive for Salmonella. Interestingly, no relationship was found between fecal coliforms and Salmonella. The presence of Salmonella in North Sea coastal water did not correlate with the presence of fecal indicator bacteria (Tobias and Heinemeyer, 1994).

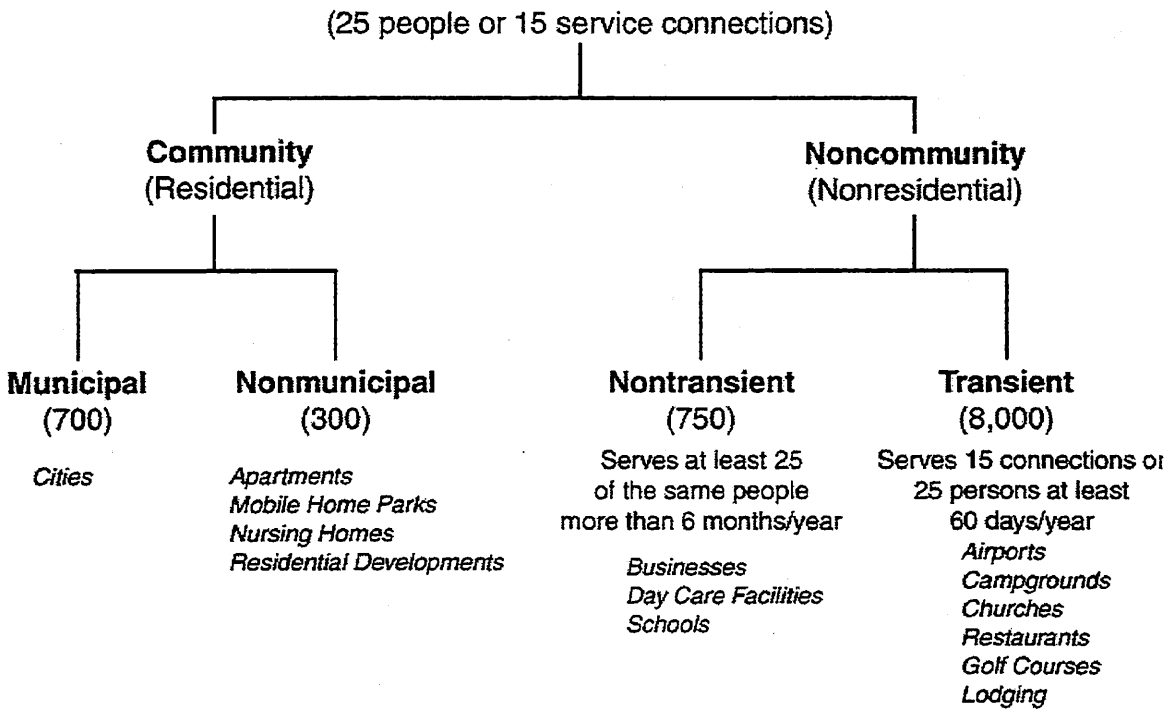
Many studies have shown that indicator bacteria are not good at predicting the virological quality of water because of their absence in water from which viruses were subsequently isolated. Lucena et al. (1994) advocated the use of Bacteroides fragilis phage to indicate the virological quality of water. They determined the concentrations of fecal bacteria, somatic and F-specific coliphages, and phages infecting B. fragilis in naturally occurring black mussels (Mytilus edulis) obtained from four sampling sites with different levels of fecal pollution. They concluded that, under the environmental conditions studied, the fate of B. fragilis phages in marine environment resembled that of human viruses more than any other microorganism examined. It is often important to determine the source of water pollution e.g., if it as human fecal pollution or animal pollution. The ratio of fecal coliform to fecal streptococci has been used to differentiate between human and animal pollution. Discriminant analysis of antibiotic resistance pattern in fecal streptococci has also been used to differentiate between human and animal sources of fecal pollution in natural waters. A total of 1,435 isolates of fecal streptococci from cattle, poultry, human, and wild-animal wastes were examined for their ability to grow in the presence of four concentrations of five antibiotics (chlortetracycline, halofuginone, oxytetracycline, salinomycin, and streptomycin). Discriminant analysis of antibiotic resistance pattern correctly classified human versus animal isolates at an average rate of 95% (Wiggins, 1996).

Male-specific bacteriophage (MSB) have been advocated as indicators of fecal pollution. To compare the relative impact of animal and human fecal wastes on the densities of MSB, Calci et al. (1998) examined 1,031 fecal samples from animals and humans in addition to 64 sewerage samples. All animal species were found to harbor MSB, although the great majority excreted these viruses at very low levels. They concluded that in areas affected by both human and animal wastes, wastewater treatment plants were the principal contributors of MSB to fresh, estuarine, and marine waters.

Authority for drinking water protection in Minnesota:

The Environmental Health Division of the Minnesota Department of Health (MDH) is responsible for protecting Minnesotans from potential health hazards in the drinking water, restaurants, lodging facilities, homes, places of work, and the broader natural environment (Fig. 1). The hazards are not limited to pathogens; radiation, and physical and chemical contamination are also of importance.

Fig. 1: Types of public water supply systems



The following discussion addresses various programs for protecting drinking water quality:

The Drinking Water Protection Program is designed to enforce the federal Safe Drinking Water Act (SDWA) for public water supply (PWS) systems across Minnesota (Fig. 1). The areas of oversight include:

- to evaluate water quality sampling and analysis standards required by the SDWA and to ensure that performance of PWS systems in Minnesota meet or exceed the SDWA standards (Table 22).

- routine and regular testing of drinking water by PWS sanitarians in close cooperation with PWS system operators (Fig. 2).

- certification and training of PWS operators.

- administration of the federal Drinking Water Revolving Fund (DWRF) which provides loans to PWS systems for upgrades to meet water quality criteria.

- regular sanitary surveys of the PWS systems, including wells and distribution systems.

- plan review of all PWS system modifications and upgrades, including watermains.

- protection from contamination of public drinking water sources (including groundwater wells and surface water) through the Source Water Protection program, to help public water suppliers properly manage the area which recharges water to their drinking water sources.

- A Nitrate Work Group was formed to develop a nitrate contamination mapping program and to (i) identify areas with nitrate contamination in the state; (ii) identify hydrogeologic and well construction factors that control nitrate distribution in groundwater; (iii) determine if nitrate contamination problems are increasing, decreasing, or remaining the same across the state; and (iv) develop guidelines to prevent further non-point source contamination.

The Health Risk Assessment Program evaluates many types of potential health hazards. With regard to drinking water, this program:

- evaluates health risks from chemicals that have been, or potentially could be, detected in drinking water sources of either surface water or groundwater origin in Minnesota.

- evaluates National Primary Drinking Water Standard for each chemical and if these standards provide adequate protection for drinking water conditions in Minnesota.

- establishes Health Risk Limits in Minnesota drinking water (Table 22).

Fig. 2: Number of Community PWS Systems that Exceed Safe Drinking Water Standards

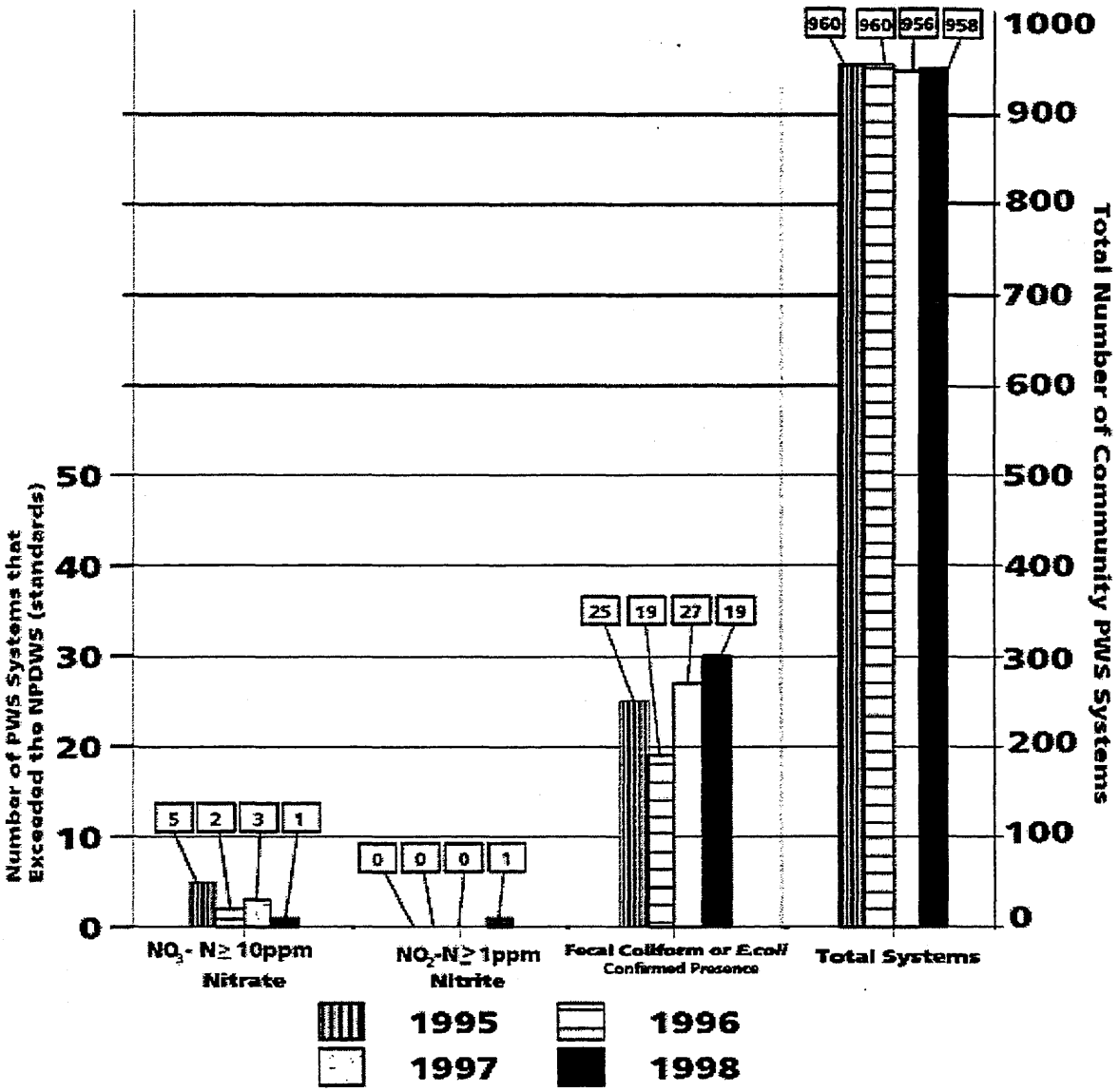


Table 22. Standards for Nitrate, Nitrite (as Nitrogen) and Bacterial Contaminants

				MDH Health Risk Limits
Contaminant	MCLG *	MCL **	BAT #	HRL
Nitrate (as NO_3-N)	10 mg/L	10 mg/L	a, b	10 mg/L (or ppm)
Nitrite (as NO2-N)	1 mg/L	1 mg/L	a, b	(none established)
Total Nitrate + Nitrite (as N)	10 mg/L	10 mg/L	a, b	(none established)
Total Coliform	absence	presence+	c	(none established)
Fecal Coliform or E. coli	absence	presence	c	(none established)

* MCLG: Maximum Contaminant Level Goal: This is broadly considered to be an ideal limit, but is not an enforceable goal, if it is lower than the MCL.

** MCL: Maximum Contaminant Level: This is a specific enforceable standard. Where the MCL is equal to the MCLG, it supercedes the goal and becomes an enforceable limit.

# BAT: Best Available Technology: These water treatment processes are considered to be capable of removing the contaminant to meet the NPDWS limits, as follows:
a = ion exchange a treatment method by which the contaminant is chemically removed from the potable water supply.
b = reverse osmosis a treatment method by which the contaminant is removed from the potable water supply by a chemical pressure gradient.
c = disinfection and/or protection of wells from contamination by appropriate placement and construction of the wells.

+presence: All PWS systems test for coliform bacteria. They need only determine the presence (positive) or absence (negative) of total coliforms (rather than a total count). If a PWS sample has a positive result for total coliforms, it must be confirmed by repeat sampling. A determination must be made if the water is positive for fecal coliforms or E. coli. If the samples are positive for total coliforms, fecal coliforms, or E. coli, then the PWS system must notify the State, and issue a public notice for its consumers (as provided by the Code of Federal Regulations, title 40, chapter I, part 141, subpart C, section 141.21). The MDH PWS program requires a boil advisory be published, as part of the public notice.

The Site Assessment and Consultation (SAC) Program investigates environmental hazards at identified sites. In regard to drinking water, this program:

- investigates the source of the hazard e.g., landfills, spills, and illegal or improperly

designed disposal sites in cooperation with any other state agency with oversight authority and with the Minnesota Pollution Control Agency.

- identifies the areal extent of the hazard in surface water and/or groundwater and how the hazard is spreading downstream or to other parts of the aquifer.

- identifies drinking water sources (wells or surface water intakes) that could be impacted by the hazard.

- identifies whether any contaminants associated with the hazard may need evaluation by the Health Risk Assessment Program e.g., any chemical which does not currently have a National Primary Drinking Water Standard or Health Risk Limit.

The Policy, Program, and Analysis (PPA) Program evaluates proposals for development in Minnesota, which meet certain established thresholds for state-level review. In regard to drinking water, this program:

- reviews many types of projects, to ensure that drinking water sources are adequately protected, and that all requirements of the state Public Water Supply program, the state plumbing code, and the state code for wells and borings are being met.

- the following lists most of the programs under which project reviews are conducted:
  -Federal Environmental Assessments;
  -Environmental Assessment Worksheets;
  -Environmental Impact Statements;
  -Alternative Urban Areawide Reviews);
  -Department of Trade and Economic Development projects;
  -Housing and Urban Development projects;
  -other special reviews

- the following types of projects are included in the above review program categories:
  -new, enlargement, or improvement of existing, federally-regulated facilities, such as airports, corrections facilities, pipelines, electrical transmission lines, etc.;
  -new residential and/or suburban development;
  -housing rehabilitation, including low- and moderate-income rehabilitation;
  -sewer and water improvements, and extensions of services to new areas of development;
  -new, or repair of existing, flood-control facilities including dikes, levees, stormwater conveyances, etc.;
  -new construction, and structure rehabilitation, within the 100-year floodplain;
  -agricultural feedlots;
  -new, or improvement of existing, transportation corridors (e.g., roads).

Water Quality Standards in Minnesota:

Public Water Supply (PWS) water quality standards are initially established by the Environmental Protection Agency (EPA) on the basis of the existing scientific literature concerning treatment technologies and occurrence of each particular contaminant. These standards are called the National Primary Drinking Water Standards (NPDWS) and are legally enforceable at public water supplies.

The MDH has additionally reviewed the scientific literature, and has performed health risk analyses for numerous contaminants, while also considering the particular environment and expected uses of that contaminant in Minnesota. The MDH Health Risk Limits (HRL) are usually as stringent, or more stringent, than the EPA NPDWS; but they are advisory in nature and are not legally enforceable. However, there are many chemicals which have had a health risk analysis done by the MDH for which there is no limit established by the EPA, and vice versa in a few cases (Table 22).

Nitrates:

Nitrates are natural compounds composed of one nitrogen and three oxygen atoms. Nitrate is very soluble in water. Nitrate can be derived from various biological and chemical processes, and various biochemical reactions can affect the concentration of nitrate. Nitrogen inputs into the soil include natural nitrogen fixation by plants, plant decay, decay of human and animal manure, fertilizer addition to the soil, and certain industrial or waste disposal inputs. In some circumstances, nitrate will undergo denitrification to become nitrogen gas. When nitrogen gas is near the land surface, it will escape into the atmosphere. Under other conditions, the nitrogen will undergo nitrification and dissolve in downward-percolating rainwater to form nitrate. Nitrate is easily transported through the soil, and can leach downward through soil and bedrock aquifer(s) to the water table. When the nitrate gets to the water table, it can move easily through the aquifer with water. Under some aquifer conditions, it can remain as nitrate for a substantially long time; under other conditions, it can denitrify to form nitrogen gas. With so many complex and competing reactions possible, if humans prevent excessive nitrogen inputs at the land surface, nitrate concentrations in groundwater can improve (i.e., diminish) with time.

Water samples can be easily and cheaply tested for nitrate. Nitrate results are reported as some value equivalent to the nitrogen content only, and is read as nitrate-nitrogen (abbreviated NO_3-N). The units are in milligrams per liter (mg/L) or as parts per million (ppm), depending on how the laboratory procedure is done. (These units are, for most purposes, equivalent).

Nitrate represents a health risk to infants under the age of six months, because it can cause an acute and potentially fatal condition called methemoglobinemia. (This is the so-called blue baby syndrome because the oxygen in an infants system is removed from the blood in a biochemical reaction involving the nitrate; thus they appear to be suffocating.) The National Primary Drinking Water Standard (NPDWS) or drinking water limit for nitrate-nitrogen, set by the United State Environmental Protection Agency (EPA), is 10 mg/L (10 ppm). Infants, and

pregnant and nursing mothers, are advised to not drink water from any source with nitrate-nitrogen levels exceeding this standard.

Surface Water Treatment Rule:

Surface waters (streams, rivers, lakes, wetlands, overland runoff, etc.) have been shown, through repeated testing, to carry contaminants from the land surface. Such contaminants, including organic and inorganic chemicals as well as microbiological pathogens, can come from both, natural and human influences on the environment. Some of those contaminants can cause a risk to the health of anyone drinking from a surface water source. However, some PWS systems must rely on surface water source(s), due to the lack of groundwater availability, or the cost of obtaining groundwater. There are 23 PWS municipal systems in Minnesota which rely directly upon surface water supplies (Table 23).

Table 23. Minnesota municipal surface water supplies

Community	Population Served	Source	Community	Popula-tion Served	Source
Aurora	2,225	St. James Mine Pit	International Falls	8,686	Rainy River
Beaver Bay	150	Lake Superior	Mankato	31,477	Minnesota River + Blue Earth River
Biwabik	1,428	Canton Pit	McKinley	230	Corsica Pit
Chisholm	5,170	Fraser-Humphrey Pit	Minneapolis	480,526	Mississippi River
Duluth	85,511	Lake Superior	Moorhead	30,200	Red River
E. Grand Forks	8,000	Red Lake River	St. Cloud	58,253	Mississippi River
Ely	3,982	Burntside Lake	St. Paul	395,988	Vadnais Lakes + Mississippi River
Eveleth	5,000	St. Mary s Lake	Silver Bay	1,950	Lake Superior
Fairmont	11,506	Budd Lake	Thief River Falls	8,285	Red Lake River
Fergus Falls	12,600	Wright Lake (Otter Tail River)	Two Harbors	3,651	Lake Superior
Grand Marais	1,217	Lake Superior	Virginia	11,495	Missabe Mountain Mine Pit
Hoyt Lakes	2,348	Colby Lake	----	----	----

The Surface Water Treatment Rule (SWTR) is an EPA Rule which requires water treatment in lieu of water testing because it regulates contaminants which are difficult to detect,

yet pose acute health risks. Outbreaks of waterborne diseases, such as giardiasis, have been linked to untreated drinking water from surface water sources. Recent research has determined that microbial diseases which were previously poorly understood, such as cryptosporidiosis, may endanger public water supplies which are inadequately treated. For example, the Cryptosporidium outbreak in Milwaukee may have made as many as 400,000 people ill in 1993. Numerous human diseases can be transmitted by both wild and farm animals. In addition, many pathogens can remain viable for a considerable time after leaving the host animal (Von Huben, 1991). Table 24 lists EPA standards for pathogens and associated water quality for PWS systems which have surface water sources, or where the groundwater may be directly influenced by a surface water source (U.S. EPA, 1995).

Table 24. EPA Standards for surface water treatment

Contaminant	MCLG
Giardia lamblia	0
Viruses	0
Legionella	0
Turbidity *	non-turbid
HPC **	none

* Turbidity is the amount of particles in water which do not readily settle out of water, including such items as clays, fine silts, and some colloidal materials. A non-turbid water sample has visual clarity. It is measured using laboratory or field equipment which passes a light through the sample, and determines the level of light which is deflected (or refracted) by particles. The result is given as, "Nephelometric Turbidity Units,"or NTU. Studies have demonstrated that suspended particles reduce the effectiveness of disinfection.

In addition, many pathogens frequently attach or adsorb to particles in water; and, in doing so, they have been shown to be able to "hide" from the disinfectant. Therefore, the turbidity of the water is important to reduce and control by treatment methods. The residual turbidity after treatment is a significant parameter in evaluating the effectiveness of the treatment method.

** HPC means the heterotrophic plate count bacteria. These are bacteria that can be identified using a laboratory technique called the plate count method. Many of these bacteria would not normally be a danger to persons in good health, but can cause severe sickness, or even death, to vulnerable populations (Von Huben, 1991).

An explosion of research in the last several years has brought to light numerous other potential health risks from newly discovered strains of bacteria, new viruses only recently identified, and protozoal parasites. With increasing use of antibiotics in raising animals, especially broad-spectrum antibiotics as well as those routinely used in humans, it may be

predicted that more-resistant strains of these pathogens, as well as new mutants, will emerge. In fact, it is likely they will emerge at rates that outpace the ability of scientists to identify, classify, and determine effective treatments against them.

The Surface Water Treatment Rule became law on December 31, 1990. It requires water treatment for PWS systems using surface water, or using a groundwater source which is considered to be under the direct influence (UDI-GW) of surface water. Examples of some groundwater sources which fall into this category are shallow wells, springs, wells in creviced or cavernous formations, infiltration galleries, and wells near a body of surface water. These are water sources that are considered to be in danger of surface water contamination (Von Huben, 1991). Each state was required to identify which PWS systems are considered UDI-GW systems within 5 years of the effective date of the law. The MDH PWS program determined that there are no UDI-GW municipal community systems in Minnesota.

The Surface Water Treatment Rule requires disinfection of all surface water systems and the UDI-GW systems. The rule also requires filtration by each of these PWS systems, unless a system can meet certain additional, stringent water quality criteria. This is a performance-based rule and the standards set by this rule are given in Table 25 (U.S. EPA, 1995). However, systems with poor source water quality may be required to meet higher reduction goals in order to ensure adequate protection (Von Huben, 1991). The MDH requires that all PWS surface water systems must disinfect as well as filter their water.

Table 25. EPA Performance Standards for Surface Water treatment

Criterion	Standard
Turbidity	< 5 NTU at all times < 0.5 NTU in 95% of all samples
Disinfection	
Giardia	99.9% effective
Viruses	99.99% effective
Residual	0.2 mg/l at entry

Rather than attempting to directly measure Giardia cysts or viruses, this rule requires systems to demonstrate that they routinely meet the above criteria, on the basis of what combination of treatment methods are used (such as, sedimentation and/or filtration, and disinfection), and how well the treatment plant is operated. In addition, the SWTR requires protection of source water.

The sedimentation process allows suspended solids to settle out of raw water, which also removes a large number of microorganisms. A coagulant, such as alum, an iron salt, or a

polymer is often used for quicker and more efficient sedimentation. When raw water is filtered through a bed of granular material (usually sand and/or anthracite), a large percentage of microorganisms is removed along with suspended matter and particles.

Disinfection involves the addition of a specified chemical to water which has already passed through a sedimentation and/or filtration process. If a sufficient quantity of the disinfectant remains in contact with the water for a specified time, microorganisms will be killed or inactivated. Chlorine is the most common disinfectant used for drinking water in the U.S., but ozone, chlorine dioxide, and chloramines are also frequently used. The computation used to ensure that disinfection is adequate is known as "CT," which multiplies the concentration (C) of the disinfectant by the time (T) in contact with the water. This computation is used to derive the removal/inactivation performance for Giardia and viruses.

Source Water Protection Program in Minnesota:

Public water systems using surface water, must strive to protect their sources from contamination (Von Huben, 1991). The Source Water Protection (SWP) program at MDH has been established to help public water suppliers establish and implement protection plans for their water sources. Community PWS systems and non-transient non-community PWS systems (Fig. 1) are required to develop such plans and hence the following discussion is confined to those systems only. There are approximately 1750 PWS systems which will be developing their plans over the next seven years.

The MDH SWP program developed the Minnesota Wellhead Protection Rule, based on the requirements established by the EPA. The PWS systems were rank-ordered, based on vulnerability of their water source and population served. The higher the rank, the sooner each system will be phased into the planning process. Each PWS system will need to identify where their water sources are recharged; that is, the area over which precipitation accumulates and then travels to the water intake, over a period of 10 years. For a well, the recharge area will be delineated as the land over which water moves into the soil, and then to the well through an aquifer. An assessment of aquifer vulnerability to contamination is conducted to determine the scope of the plan for managing potential contamination sources. For surface waters, the recharge area includes those areas within the watershed which are higher (upgradient) than the water intake.

The next part of the process is developing a plan for source water protection. A commitment of local people served by the PWS (the community, or the owners of the non-transient non-community system) is necessary to develop the plan. This local planning group must understand what potential there may be for contamination, and how to address that potential. This requires developing some additional information about the recharge area, including: what land uses now exist within the recharge area; which uses, if any, have a potential to contaminate the water; and how to evaluate the costs and benefits of different land uses and compare them with the costs of treatment, in the event of contamination. The local planning group must also decide what types of land uses they consider appropriate, and which land uses they feel may need to be addressed by management strategies. The final part of the process is the

implementation of the plan and the enforcement of any ordinances. The entire planning process is facilitated by planners from the MDH SWP program, who will also provide educational references as needed; however, all decisions will be locally made and enforced.

Source Water Protection Program for Major Cities:

The cities of Minneapolis, St. Paul, and St. Cloud have joined together in a Clean Water Partnership project, called the Upper Mississippi River Source Water Protection Initiative. As part of this project, MDH will be working with these cities to prepare plans for protecting their surface water intakes. The cities have been testing for Cryptosporidium and feel that their treatment plants will handle any pathogen that may be present in their intake water. However, they want to take a proactive approach to identifying all potential contamination sources which may impact their water supply. It will be about two years before the source water plans for the cities of Minneapolis and St. Paul are drafted.

5. To what extent are surface waters affected by or at risk from allowing pastured animals access to surface waters?

Grazing by livestock has been reported to have numerous interrelated effects on the landscape which directly or indirectly affects water quality. There is a continuum of effects, most reported degradation of water quality is related to overgrazing. A general conclusion is that unmanaged grazing leads to overuse and degradation, primarily in riparian areas (Fitch and Adams, 1998). Grazing has a myriad of effects on the landscape. Heavy grazing can reduce vegetative cover, compacts the soil, reduces infiltration, increases runoff, erosion and nutrient and sediment yield. In riparian zones, trampling the streambanks decreases erosional resistance of the streambank and contributes to sediment yield (Trimble and Mendel, 1995), vegetation removal increases solar insolation and leads to higher stream water temperature (Li et al., 1994). Excrement input either in the uplands or into water bodies can lead to elevated levels of pathogens. Fish and aquatic invertebrates are sensitive to sediment input, water temperature and excess algae and plant growth due to nutrient input (Waters, 1995).

In contrast, low or moderate grazing have effects that are much less significant than heavy or unmanaged grazing (Trimble and Mendel, 1995). However, relatively few comprehensive studies have been done at the watershed level about the environmental impact of pastures. Correll (1996) concluded that low intensity grazing of pastures that are not fertilized does not usually cause significant nutrient or sediment impacts on surface waters, unless livestock have unconstrained access to water and/or the riparian buffers. Due to efficient nutrient recycling, these low intensity systems are similar in impact to native vegetation and very much better than annual row crop systems. On the other hand, pastures that receive heavy applications of fertilizer or stored manure often harm receiving waters, and their impacts can exceed those of annual row crop systems. Correll (1996) concluded that rotational grazing reduces impacts, whereas winter grazing increases impacts.

Most studies in our literature search have reported on effects in the arid,western United States (see reviews by Kauffman and Krueger, 1984; Platts, 1991; Fleischner, 1994; Trimble and Mendel, 1995; Fitch and Adams, 1998; Larsen, 1998; Strand and Merritt, 1999 and bibliography by Van Deventer, 1992). Larsen et al. (1998) suggest that caution should be used when interpreting most past literature, because many studies were not experimental with replicated treatments and statistically valid results, rather they are before and after treatments with no baseline data. Very little literature has been conducted and published for grazing practices in the Midwest.

Sediment

Sedimentation is recognized as the most prevalent and damaging pollution in streams in North America (Waters, 1995). In streams surveyed in 1996, the most common agricultural pollutant was silt, which was a contributing factor for 50 % of streams considered impaired (USEPA, 1996). Sediment associated with livestock grazing occurs during snowmelt or heavy rainfall, when removal of vegetation and compaction combine to facilitate overland flow

(Gardner, 1950; Bryant et al., 1972; Owens et al., 1983; Orodho et al., 1990). In addition to snow melt during winter or spring, rainfall intensities of 1.0 to 1.4 inches/hour can be expected on average every two years across Minnesota (Huff and Angel, 1992). This means that significant runoff is likely to occur at any given site on an average of every other year, because few soil conditions allow infiltration of this precipitation rate. As with other loss pathways, runoff amounts will vary with soil, weather, plant, and animal factors. For example, in the Netherlands, runoff occurs even on gently sloping soils in winter, because precipitation exceeds the infiltration capacity of heavy-textured soils (Steenvoorden et al., 1986). The fate of many pollutants in water bodies is determined by the sorption, storage, and transport by sediment (Fairchild et al., 1987; Taylor et al., 1994). Sedimentation from livestock grazing can be heavy enough to blanket stream beds with silt, but more commonly, leads to a gradual decrease in the depth of pools (Quinn et al., 1992; Sidle and Sharma, 1996).

Many invertebrates in streams require relatively silt-free habitats. These organisms live in the interstitial spaces between rocks in the bottom of streams (Minshall, 1984). Excess amounts of sediment deposited in the stream bottom, can fill spaces between rocks (interstitial spaces), thereby reducing suitable habitat. Invertebrates that require interstitial spaces tend to decline along with their habitat, and are usually replaced by burrowing taxa which prefer silt habitats (Lenat et al., 1979; Lenat et al., 1981; Lemly, 1982). Taxa that dwell in interstitial spaces are generally the most important prey items for fish that feed on invertebrates; burrowing taxa are not as desirable as food items (Waters, 1995). Siltation of cobble and gravel also covers hard substrates required for algal growth. Thus, invertebrates that scrape algae from hard substrates for food will decline, whereas invertebrates that filter food from the water column will increase. The density of invertebrates may decrease with the loss of invertebrates sensitive to siltation, but often densities remain the same or even increase due to high abundances of burrowing taxa (Lenat et al., 1979). Invertebrate diversity is often reduced with siltation because of the loss of intolerant species (Lemly, 1982).

Olness et al. (1975) provide a comparison for sediment delivery watersheds with rotational grazing, continuous grazing and croplands in Oklahoma. Precipitation was similar across watersheds. Runoff ranged from 4 to 13 in, with the highest values for two continuously-grazed watersheds. Associated sediment delivery was highest for the two continuously-grazed watersheds (8 and 10 tons/ac), but had the highest erosion index, none of the other watersheds yielded more than 4.4 tons/ac. One rotationally-grazed watershed yielded the lowest sediment (0.5 ton/ac), and the other was similar to wheat and alfalfa fields (~ 1.0 ton/ac). Three watersheds devoted to cotton had sediment yields from ~ 2.0 to 4.0 tons/ac.

Mwendera and Saleem (1997a) report heavy to very heavy grazing pressure (1.2 to 1.7 animal-unit-months ac^{-1} significantly increased surface runoff and soil loss and reduced infiltrability of the soil on a natural pasture Ethiopian highlands on 0.025 ac plots. Fine textured soils were more susceptible to trampling effects than coarse textured soils, and reduction in infiltration rates was greater on soils which had been tilled and exposed to very heavy trampling (Mwendera and Saleem, 1997a). In related studies, Mwendera and Saleem (1997b) and Mwendera et al. (1997) report that for the same % vegetative cover, more soil loss occurred from plots on steep rather than gentle slopes, and that gentle slopes could withstand more grazing

pressure without seriously affecting the ground biomass regeneration compared to steeper slopes. Slopes exceeding 5.8% are likely to suffer soil erosion even under moderate grazing pressure. They recommend a need for developing 'slope-specific' grazing management rather than making blanket recommendations for all slopes.

Naeth and Chanasyk (1996) quantified the effects of rainfall and snowmelt induced runoff and sediment yield from sloped areas of the foothills fescue grasslands of Alberta, Canada. The effects of two grazing intensities (heavy and very heavy) for two durations (short duration and continuous throughout the growing season) were compared to an ungrazed control between June 1988 and April 1991. Snowmelt was the dominant source of runoff and snowmelt runoff was higher from the heavily grazed areas than from the very heavily grazed areas, due to the higher standing vegetation which accumulated snow in the former areas. However, sediment yields as a result of snowmelt were generally low in all areas. Only a few summer storms caused runoff. Runoff volumes and sediment yields from summer rainstorms were low, due to low rainfall and to generally dry antecedent soil moisture conditions. The greatest risk of summer runoff, and thus sediment yield, appears to occur in August (Owens et al., 1989; Naeth and Chanasyk, 1996).

Annual sediment concentration decreased by more than 50% and the amount of soil lost decreased by 40% during a 5-year period when cattle were fenced out of the stream relative to a 7-year period were a beef cow herd had access to a 64-ac watershed (Owens et al., 1996). Average annual soil losses were reduced from 1.1 to 0.62 ton/ac while annual precipitation averages were similar during each management period.

Owens et al. (1997) studied runoff and sediment losses from a small pastured watershed in eastern Ohio for 20 years. In Period 1, a beef cow herd grazed it rotationally during the growing season for 12 years and was fed hay in this watershed during the dormant season (high animal density with feeding). During the next 3 years of this study (Period 2) there was summer rotational grazing only. There was no animal occupancy on this watershed during the last 5 years (Period 3). Annual runoff was more than 10% of precipitation during Period 1 (4.7 inch) and less than 2% during Periods 2 and 3 (0.55 and 0.24 in, respectively). The decrease in annual sediment loss was even greater with the change in management, yielding 2015, 130, and 8 lb/ac for the three respective periods. Over 60% of the soil loss during Period 1 occurred during the dormant season. Low amounts of runoff and erosion from three adjacent watersheds with summer-only grazing supported the conclusion that the increased runoff and erosion during Period 1 resulted from the non-rotational, winter feeding on pastures. When the management was changed, the impacts of the previous treatment were not long lasting, changing within a year.

In a related study in Ohio, Owens et al. (1989) found the largest monthly average sediment concentrations were 0.8 g/L for 2 yr without the presence of livestock, 1.3 g/L for 3 yr with 17 cows grazed during the summer months only, and 3.2 g/L for an additional 6-yr period with all-year grazing with hay being brought in for winter feed. Annual sediment losses were 0.09, 0.53, and 0.94 ton/ac, respectively, across the three grazing levels.

After exclusion of grazing ("retirement") from the banks of most perennial streams,

erosion-prone hillslopes, and remnant pockets of native forest from a 28 mi^2 mixed pasture/forested watershed in New Zealand sediment loads changed by -85% (Williamson et al., 1996).

Gilley et al. (1996) report sediment concentration in runoff was significantly higher in twice-over rotational grazing and season-long grazing than undisturbed CRP land, but was less than areas that were hayed or burned in North Dakota even though the amount of runoff was similar (Table 26).

Table 26: Soil Loss from Fields Differing in Grazing Practice.

Sediment Treatment	Soil Runoff	Conc.	Loss
	(in)	(ppm $x10^3$)	(lb/ac)
Undisturbed	0	0.00	0
Grazing (twice)	1.2	1.57	401
Grazing (season)	1.2	1.62	401
Hayed	1.1	2.30	508
Burned	1.5	2.28	1008

Summary of sediment effects:

- Sediment yield increases with increasing grazing pressure, lowest levels related to ungrazed or "retired" riparian areas.
- Fine textured soils were more susceptible to trampling effects than coarse textured soils.
- Soil loss increases with steeper slopes.

Pathogens

Due to the threat of contamination of drinking water by pathogenic microorganisms, livestock excrement input to streams is an important human health concern (Strand and Merritt, 1999). Fecal material deposited along or directly into streams elevates concentrations of phosphorus and nitrogen (Lemly, 1982). Concentrations in runoff water can be several orders of magnitude larger than contact standards (Giddens and Barnett, 1980; Coyne and Blevins, 1995). Similarly large concentrations of pathogens can occur in runoff from pastures that do not receive stored manure, due to defecation by wildlife and cattle (Edwards et al., 1993). Nutrient enrichment can lead to increased production of heterotrophic microbes that can reduce dissolved oxygen concentration (Harris et al., 1994).

Bacteria from livestock can enter streams in runoff or are deposited directly when animals have access to the stream (Sherer et al. 1988). Benthic sediments have been found to harbor significantly higher concentrations of enteric bacteria than the overlying water. Fecal coliform

and fecal streptococci organisms have demonstrated significantly longer survival, half-lives from 11 to 30 d and 9 to 17 d, respectively in sediment laden waters than in those without sediment (Sherer et al., 1992). Sherer et al. (1988) artificially resuspended stream sediments at three sites on five occasions in a watershed with active grazing. They found 0.02 to 8.2 billion fecal coliform ft^{-2} and 0.009 to 60 billion fecal streptococci ft^{-2} during the resuspending trials. The higher counts were related to cattle access to the stream.

Edwards et al. (1997) found there were no consistent relationships between the presence of cattle and fecal coliform and fecal streptococcus runoff concentrations from four Northwest Arkansas fields over three years. Runoff amount had no effect on runoff concentrations of fecal coliform or fecal streptococcus. Each field was grazed and fertilized, with two fields receiving inorganic fertilizer and two receiving animal manure. Higher concentrations were observed during warmer months. Runoff FC concentrations exceeded the primary contact standard of 200 Colony Forming Units/100 mL during at least 89 percent of all runoff events and the secondary contact standard of 1000 CFU/100 mL during at least 70 percent of the events. In contrast, Teidemann et al. (1987, 1988) found significant increases in fecal coliform with increased intensity of grazing management in Oregon across 13 watersheds with four management strategies. Two watersheds with the highest level of grazing management exceeded 200 fecal coliform 100 mL-1 (Tiedemann et al., 1987, 1988). Gary et al. (1983) report bacteria densities were significantly higher along a pasture when 150 cattle were grazed compared to when 0 or 40 cattle were grazed in a Colorado front range stream.

Summary of references dealing with pathogens:

- There are conflicting reports on the effects of grazing intensity and fecal coliform delivery to streams.
- Bacteria from livestock can enter streams in runoff or are deposited directly when animals have access to the stream.
- Benthic sediments harbor significantly higher concentrations of bacteria than the overlying water.

Temperature

Temperatures during summer and winter were significantly different among three streams in Pennsylvania, at least in part, related to the absence of shading due to a nearly complete lack of woody vegetation along two streams which were grazed (Wohl and Carline, 1996). Riparian forest clearing in the northeastern U.S. resulted in increases in temperature of from 3.6-9.0 degree F (Sweeney, 1993). The ungrazed stream was warmest in winter, coolest in summer, and had the narrowest range of mean daily temperature. In general, abundance and diversity of macroinvertebrates was highest in the ungrazed stream, which also supported the highest abundance of brown trout (Wohl and Carline, 1996). Carline and Spotts (1998) report that the two streams in the Wohl and Carline (1996) study responded favorably to stream bank fencing, bank stabilization and the installation of rock-lined aminal crossings. They found that total dissolved solids decreased by 50%, macroinvertebrate density increased by at least 70% in the

two streams.

Li et al. (1994) reported that watersheds in eastern Oregon with greater riparian canopy, had higher standing crops of rainbow trout, lower daily maximum and perennial flow. Algal biomass was positively correlated with solar insolation. Total invertebrate biomass, and herbivorous invertebrate biomass was also positively correlated with algal biomass in all watersheds studied.

Quinn et al. (1992) state that small streams in New Zealand intensively grazed by cattle had greatly reduced shading by riparian vegetation, resulting in substantial increases in daily maximum temperatures during summer. Higher daily thermal fluctuations have also been associated with increased solar insolation (Kauffman and Krueger, 1984). In general, Quinn et al., 1992) found invertebrates favoured by cool water and low periphyton abundance decreased in density. Differences in physical habitat and invertebrate communities were minor between paired grazed and riparian-protected reaches of the larger where grazing by cattle and/or sheep had little or no effect on stream shading.

Overview of temperature effects:

- Removal of streamside vegetation can increase mean temperature and temperature extremes.
- Streams along wooded riparian zones may be cooler in summer and warmer in winter.
- Relatively small changes in stream temperature can shift aquatic communities
  - a 3.6 degree F increase is sufficient to shift from a coldwater to warmwater assemblage.
  - an increase in stream temperature from 3.6 to 9 degree F is common when streamside vegetation is removed.

Nutrients

Timmons and Holt (1977) provide levels of nutrient loss from a native prairie in west-central Minnesota that can be used to compare the effects of different grazing levels on nutrient loads in runoff. Depending on the nutrient of interest, 63 to 88% of the average annual nutrient loads were transported in snowmelt; however, averaged weighted concentrations for all chemical constituents were higher for runoff following rainfall. Total nitrogen and total phosphorus losses averaged 0.7 and 0.09 lb/ac, respectively, over a five year period. Cation losses ranged from 0.09 to 1.6 lb/ac and the order was K > Ca > Mg > Na in four of five years.

Elevated levels of nutrient input often results in dense growths of filamentous green algae, i.e., *Cladophora* spp. These dense growths differentially promote the production of some insect species, that replace a diverse assemblage of attached photosynthetic microorganisms. In addition, many herbivorous insects decline in abundance in response to dense filamentous blooms (Li et al. 1994). The dense filamentous algae reduces feeding efficiency of insectivous fish due to a switch in the insect prey base (Tait et al., 1994).

Cooper et al. (1995) found that during 12 years after retirement from grazing, dominant vegetation in the set-aside areas changed from pasture grasses to native tussock in pasture along the edge of a small stream in New Zealand. Riparian set-aside soils had an extremely high hydraulic conductivity in the surface horizon (250 inch h^{-1}) compared with that in the riparian grazed pasture (0.6 in hr^{-1}) indicating that surface runoff water transported into the zone would infiltrate, fill soil pores and emerge as subsurface flow at the stream edge. Phosphorus available for transport was highest in riparian set-aside soils, indicating P saturation of the zone. Nitrate pool size was strongly correlated to nitrifying potential, with both being extremely low in riparian set-aside. Microbial biomass was greater in riparian set-aside (1900 mg C g^{-1}) than riparian native (1460 mg C g^{-1}) or riparian pasture (1080 mg C g^{-1}). Cooper et al. (1995) imply that riparian set-aside has led to the development of a zone likely to supply runoff to the adjacent stream that is depleted in sediment-bound nutrients and dissolved N but enriched in dissolved P.

Owens et al. (1994) determined that concentrations of NH4-N, NO3-N, and total N increased throughout a 5-yr period of 200 lb N/ac annual fertilizer application to a grass-pasture grazed by beef cattle and reached levels that were usually in excess of 10 mg N/L. NO3-N concentrations in groundwater dropped rapidly after alfalfa was interseeded into the grass pastures and N fertilizer was no longer applied. NO3-N levels decreased from 17.7 to 9.3 mg N/L in a tall fescue-alfalfa area, whereas in two orchardgrass-alfalfa areas, levels decreased from 11.2 to 2.7 and from 8.3 to 3.6 mg N/L. The amount of N lost via subsurface flow decreased, but subsurface flow remained the main pathway for N loss compared with surface runoff or sediment-attached N (Owens et al. 1994).

In a related study in Ohio, Owens et al. (1989) found nutrient concentrations remained low across three grazing levels, with the exception of K concentration, which increased with all-year grazing. Concentrations of NO3-N, mineral-N, P, Ca, Mg, Na, and Cl were similar to or less than the concentrations from a nearby 43.7-ac wooded watershed that contained no pastured areas and received no agricultural inputs. Largest monthly average sediment concentrations were 0.8 g/L for 2 yr without the presence of livestock, 1.3 g/L for 3 yr with a 17 cows grazed during the summer months only, and 3.2 g/L for an additional 6-yr period with all-year grazing with hay being brought in for winter feed. Annual sediment losses were 0.09, 0.54, and 0.94 ton/ac, respectively across the three grazing levels. Although relatively few pastures are grazed in winter in Minnesota due to deep snow or cold conditions, increased use of grazing to provide feed for cattle, especially, implies that farmers need to keep pastures in good condition.

Management intensive grazing (MIG) is a grazing system designed to maximize both forage yield and quality. Cattle at a high stocking density are rotated frequently through a series of paddocks. The uneven recycling of N through feces and urine can increase NO3-N leaching. The extent to which NO3-N can leach from beneath urine and fecal spots under soil and climatic has not been studied extensively. Stout et al. (1997) determined NO3-N losses averaged across three years were 10.4, 15.0, 196.2, 214.1, and 281.0 lb ac^{-1} for the control, feces, and spring-, summer-, and fall-applied urine, respectively in a N-fertilized orchardgrass field in central Pennsylvania. These losses represent about 2% of the N applied in the feces and about 18, 28, and 31% of the spring-, summer-, and fall-applied urine N. Hack-ten Broeke et al. (1996) found that level of nitrogen leaching as the result of urination by cows depended upon soil type,

moisture conditions and grazing intensity on two experimental, rotational-grazed plots in the Netherlands. They found that NO-3-N levels rarely exceeded the European Coummunity's directive of 11.3 mg/l in a wet moderately grazed field, but was often exceeded in a drier more heavily grazed pasture. Correll (1996) indicates that pastures that receive heavy applications of fertilizer or stored manure often harm receiving waters, and their impacts can exceed those of annual row crops.

After exclusion of grazing ("retirement") from the banks of most perennial streams, erosion-prone hillslopes, and remnant pockets of native forest from a 28.3 mi^2 mixed pasture/forested watershed in New Zealand loads changed by -27% for particulate P, -26% for soluble P, -40% for particulate N, and +26% for dissolved N (Williamson et al., 1996). Calculated total phosphorus specific yields for the pasture portion of the watershed changed from 509 lb mi^{-2} yr^{-1} before retirement to 235 lb mi^{-2} yr^{-1} after retirement. Williamson et al. (1996) predicted that retirement reduced TP loads by 20% in the lake that receives runoff from the watershed. Phosphorus reduction was predicted to reduce the chlorophyll a concentration by about: 5 mg m^{-3}, and potentially shift the lake's trophic state from eutrophic to mesotrophic.

Total N in runoff from a cattle-grazed watershed ranged between <0.9 to 3.6 lb ac^{-1} yr^{-1}, whereas only 0.44 lb/ac yr^{-1} was measured in a nongrazed watershed over a three year period (Jawson et al., 1982). TN received in precipitation was equal to or greater than N lost in runoff from the grazed watershed. Nitrate-N levels in the runoff were normally <1 mg/l. Total P (TP) losses in runoff from the grazed watershed ranged from 0.09-1.2 lb ac^{-1} yr^{-1} and from <0.09 to 0.15 lb ac^{-1} yr^{-1} from the ungrazed area period (Jawson et al., 1982).

Concentrations of NH4-N, NO3-N, total P, soluble P and Cl- were 6, 45, 37, 48 and 78% greater, respectively, over a three year period were measured from a 6.2-ac cow-calf grazed pasture in Nebraska when livestock were grazing in comparison to periods when cattle were removed (Schepers and Francis, 1982). Total solids increased by 52% during grazing, but total organic C and COD only increased by 11 and 7%, respectively, whereas total Kjeldahl N concentration decreased by 19% (Schepers and Francis, 1982). Concentrations of NH4-N, total Kjeldahl N, total P, total organic C and COD were directly related to the density of grazing livestock (Schepers et al., 1982). Leachates from the standing plant material, surface litter layer, surface soil and manure deposits indicated manure and standing plant material were likely sources of most chemical constituents in runoff water (Schepers et al., 1982).

McColl and Gibson (1979) measured mean concentrations of Kjeldahl N, total P, Ca and K were 190, 150, 24 and 240 times higher, respectively, in surface runoff from a grazed and a fertilized hill pasture than those in rainfall over one year. Concentrations tended to be high in summer and were strongly related to grazing. The peak of nitrate concentration after grazing lagged approximately 2 weeks after the Kjeldahl N peak and probably depended on nitrification of ammonium from dung and urine.

Smith (1989) stated that sediment, phosphorus, particulate- and nitrate-nitrogen concentrations, during 71 run-off events over 22 months, were lower and varied significantly less at retired riparian pasture than at grazed riparian pasture sites. Smith (1989) recommends

riparian pasture retirement is an effective means of reducing surface run-off pollutant loads to waterways.

Table 27: Reduction (%) in nutrients in channelized surface run-off from two moderately steep hillslopes in New Zealand from riparian pasture retirement in relation to grazed pasture (from Smith 1989).

Water Quality Parameter	Percent Reduction
Total suspended solids	87
Volatile suspended solids	84
Particulate P	80
Dissolved P	55
Total Nitrogen	85
Nitrate-nitrogen	67

Nitrogen inputs to the Tomales, California, watershed (a rural area of 138 376 ac) from the atmosphere are about equal to outputs via runoff and groundwater flow (Freifelder et al., 1998). This balance was initially interpreted to suggest that the system was neither releasing nor taking up nitrogen. A more detailed budgetary analysis suggests otherwise. In their analysis, Freifelder et al. (1998), found that food imported for dairy cows and humans, waste management and milk export were incorporated into the nitrogen budget. Cattle contributions to the budget were influenced by nutrition as a function of age, lactation state and milk yield, as well as population density. The cow contribution distinguished grazing (i.e. internal nutrient cycling) from the introduction of nitrogen in feed grown outside the watershed, and the budget incorporated nitrogen losses due to waste management and export of milk. Food imported for cattle was almost 10 times the import for humans, but cows and humans contributed approximately equal net nitrogen additions to the system. This inclusion of cows and humans in the nitrogen budget demonstrated that nitrogen inputs to the system exceed hydrological outputs by about 1.8 lb ac^{-1} yr^{-1}. Alternative sinks which may account for this 'extra nitrogen' include storage in biomass or soil organic matter; or loss from the system by the difference between nitrogen fixation and denitrification.

Overview of nutrient effects:

- Nutrient concentrations (various forms of N and P) in runoff increase with increasing grazing intensity.
- Retiring areas from grazing but maintaining grass vegetation reduces nutrient delivery, but dissolved N may be reduced differentially in relation to dissolved P.

Vegetation Removal

Impacts of vegetation removal can be placed into two categories: shifts in community

structure and removal of biomass. Major changes in community structure and usually a reduction in the number of species have been reported in the western United States (see review by Kauffman and Krueger, 1984). Rooting depth of vegetation associated with shifts in community structure affects water uptake and soil characteristics. The impact of removal of biomass has often focused on riparian zones, because of the importance of woody vegetation to wildlife and the potential for alteration of the riparian microclimate. Cattle have significantly altered the size, shape, volume and quantities of live and dead willows. Cattle have also influenced the spacing of plants and the width of the riparian zone (Kauffman and Krueger, 1984). Riparian vegetation has a major influence on channel shape. Vegetation increases stream bank strength by binding the soil with roots and shields banks from erosion during high flows. Kauffman and Krueger (1984) report that bank sloughing increases when vegetation removal exceeds 60%. Streams with heavily vegetated riparian areas are narrower and deeper than those that flow through poorly vegetated areas.

In uplands, vegetation removal exposes soil to the energy of raindrops, facilitates sheet flow with an increase in the amount of runoff and the ability to move sediment. Rauzi and Hanson (1966) found that runoff from a heavily-grazed watershedwas 1.4 times higher than a moderately-grazed watershed and 9 times higher than a lightly-grazed watershed. Bari et al. (1995) examined the residual phytomass level necessary to adequately protect the soil against accelerated interill erosion in a temperate region of Pakistan. They found that a residual treatment with 2697 lb ac^{-1} phytomass resulted in the lowest erosion rates, whereas 557 lb ac^{-1} phytomass produced the highest erosion. Standing phytomass was the most important variable affecting erosion with foliar cover and basal cover also highly correlated to erosion.

Effects of vegetation removal:

- Vegetation removal exposes soil to the energy of raindrops, facilitates sheet flow, runoff and the ability to move sediment.
- In contrast, vegetation increases stream bank strength to resist erosion.
- Stream channels along heavily vegetated areas are deeper and narrower than along poorly vegetated areas.

Effects on Stream Morphology

Livestock grazing, as well as other land uses, can affect the energy balance in streams and produce negative effects on riparian equilibrium. There are a large number of complex, interrelated factors that determine riparian form and function that can be affected by livestock grazing which include stream discharge, sediment load, resistance of the banks and bed to movement of flowing water, vegetation and temperature. Changes in these variables will elicit an adjustment of the dynamic equilibrium of streams and their valleys. Cattle are agents of geomorphic change. Bohn and Buckhouse (1986) report streambank degradation is related both to the number of livestock grazed and the duration of grazing.

Unstable channel morphology and the loss of fish and invertebrate habitat is often attributed to cattle grazing practices in riparian areas in the western United States. Cattle grazing often causes large changes in channel morphology, causing wider, shallower stream channels (Knapp et al., 1998) with significant native vegetation overhang and extensive fish habitat to wide braided channels with little cover for fish or amphibians (Williamson et al., 1992). A number of studies have examined effects of livestock by fencing riparian areas to exclude grazing and then noting the effects on riparian vegetation and stream morphology. Magilligan and McDowell (1997) selected four gravel-bedded, steep alluvial streams in eastern Oregon with cattle exclosures greater than 14 years old for an analysis of geomorphic adjustments following the removal of cattle grazing. Reductions in bankfull widths by 10 to 20 percent and increases of 8 to 15 percent in pool area were the most common and identifiable changes in the exclosures. Not all channel properties demonstrated adjustment, leading Magilligan and McDowell (1997) to suggest that perhaps 14 years is an insufficient duration for these variables to adjust.

Platts and Nelson (1985) examined two grazed and one ungrazed reach where grazing had been excluded for 11 years. Their ungrazed section demonstrated improved riparian vegetation and a deeper, narrower channel. However, exclusion of grazing for two years along a 0.6 mi section of a stream channel that had experienced historical grazing did not lead to substantial geomorphic recovery, indicating that it may take many years for the full benefits to be assimilated by the fluvial and riparian systems (Sidle and Sharma, 1996). However, Sidle and Sharma (1996) found that shifting the location of cattle grazing caused significant downstream impacts. Cattle moved into wet riparian areas upstream, causing decreases in thalweg depth (i.e., the location of the deepest portion of the channel), increases in fine sediment deposition in the channel, and loss of pool volume in these upstream areas. They also reported increases in deposition of fine sediment in reaches with high volumes of large woody debris (Sidle and Sharma, 1996). Pool/riffle ratio (a measure of fish habitat), as well as soil and vegetation stability varied significantly with cattle density (Meyers and Swanson, 1991). As pool/riffle ratios changed, other channel properties are seen to change as well.

Clarkson and Wilson (1995) found that bank damage by ungulates was the only variable solely influenced by land management practices in a generalized linear model ($R^2 = 0.7$) relating trout biomass and stream, riparian, and geomorphic habitat variables generated from 243 stations among 21 high-elevation trout streams over four years in the White Mountains area, east-central Arizona. The bulk of the bank damage was attributed to domestic cattle grazing. Channel width, was partly dictated by geomorphology but was also correlated with bank damage by ungulates and thus could be influenced by management strategies. Platts (1984) indicates that continuous, heavy grazing resulted in a stream reach that became four times wider and one-fifth as deep as an adjacent area that was only lightly grazed.

Myers and Swanson (1995) indicate that deferred rotation grazing led to improvement of aquatic and riparian habitats along three central Nevada streams, but that complete rest from grazing allowed the most improvement. Streambank soil stability, type and amount of vegetation cover, and quality of pools responded most to changes in grazing management. Complete rest improved channel and water width:depth ratios, channel entrenchment, bank angle, bank undercut, and bank depth. Width-to-depth ratios at base flow was significantly higher along bare

ground transects.

These geomorphological changes are common, but not universal. Williamson et al. (1992) conducted a longitudinal survey which showed stock damage ranging from 0-25% of the channel length in grazed reaches. They found no statistical evidence that mixed sheep and cattle grazing on streambanks in floodplain streams in New Zealand led to rapid or severe deterioration in channel form, except in small streams (< 6.6 ft wide) under intensive grazing of wet streamside soils. They found that the dominant erosion mechanism, the undercutting of banks, was largely unaffected by grazing stream margins. As well, effects of riparian retirement on small streams varied depending on the stability of the stream channel, but was correlated with increased vegetation overhang. On larger streams with more actively meandering channels, retirement had comparatively little benefit, because any retirement or grazing effects were rapidly overtaken by channel migration. Finally, Williamson et al. (1992) concluded that, in contrast to channelization, grazing appeared only to have a minor effect on channel morphology in the streams they studied, because only very large differences could have been detected as a result of the variability in each reach.

Overview of effects due to channel morphology:

- Unstable channel morphology and the loss of fish and invertebrate habitat is often attributed to cattle grazing practices in riparian areas in the western United States.
- Stream channels along heavily vegetated areas are deeper and narrower than along poorly vegetated areas.
- Livestock management often causes local-scale changes in habitat, thereby impacting fish and invertebrates.
- Changes are much more pronounced in small streams than large ones; impacts on lakes are under-studied but appear to be minimal.
- The natural variance among stream channels, lakes and wetlands makes generic conclusions very tenuous. Most impacts and most Best Management Practices will be relatively site specific.

Measurement Techniques

Chokmani and Gallichand (1997) assessed a distributed indicator method with a geographical information system for predicting the potential for surface water pollution at the watershed scale. Water quality at the outlet of two watersheds, where animal production was dominant, was monitored on a continuous basis for one year. Observed water quality was related to land use, particularly the intense animal production. Chokmani and Gallichand (1997) found NH4-N, TP, dissolved oxygen and fecal colimorms affected surface water quality. Differences were noticed between observed water quality and that predicted by their model. They attributed

the differences to neglecting some nutrient and sediment transport processes. However, their model identified zones, within each watershed, that could contribute to water pollution.

Fraser et al. (1998) present a geographical information system (GIS)-based transport model (SEDMOD) that provides an index of pathogen loading potential to streams by characterizing five key transport parameters: flow-path hydraulic roughness, gradient, and slope shape, stream proximity, acid a normalized soil moisture index. The SEDMOD model was applied to 12 subwatersheds (10 agricultural, 2 forested controls) of the Saw Kill, a tributary of the Hudson River, New York, and compared model predictions with measured fecal coliform (FC) levels. The transport model, combined with a livestock density GIS layer, could explain 50% of the variation in average FC discharge among the subwatersheds. In a multiple regression, predicted FC transport, mean water temperature, and mean turbidity could account for 80% of the observed variation in FC discharge.

Management Strategies

Godwin and Miner (1996) demonstrated that off-stream watering areas are an effective alternative to stream fencing. Off-stream watering reduced the time animals spend at the stream under small acreage grazing conditions. An animal-operated pasture pump that pulled water from the creek was demonstrated to be a viable off-stream watering device. Sheffield et al. (1997) found that when given the choice, cattle drank from an off-stream water trough 92% of the time, compared to the time which they spent drinking from the stream on two commercial cow-calf operations in southwest Virginia. Stream bank erosion was reduced by 77%, as were concentrations of total suspended solids (90%), total nitrogen (54%), and total phosphorus (81%) when an alternative water source was provided. Similar reductions were observed in concentrations of fecal coliform and fecal streptococcus. Concentrations of nitrate and orthophosphorus were not reduced.

Conclusions:

Overgrazing or unmanaged grazing can:

- Reduce vegetative cover and infiltration,
- compact the soil,
- increase runoff, erosion and nutrient and sediment yield.

In riparian zones, trampling the streambanks can:

- Decrease erosional resistance of the streambank and contributes to sediment yield.

- Vegetation removal increases solar insolation and leads to higher stream water temperature.

- Manure either in the uplands or into water bodies can lead to elevated levels of nutrients and pathogens.

- Fish and aquatic invertebrates are sensitive to sediment input, water temperature and excess algae and plant growth.

Low or moderate grazing have less significant effects than overgrazing

- but note caution voiced by Larsen et al. (1998)
  -current literature contains many studies that are not experimental with replicated treatments and statistically valid results.

- Little information relevant to upper Midwest is available in the literature.

Future needs

While it is clear that grazing can degrade water quality most work has been conducted in the arid western United States and not under the conditions prevalent in the Midwest. Future research should be directed toward replicated studies under controlled conditions that examine causation that should lead to better management practices and better policies (Clark, 1998). With few exceptions, little is known in the Midwest about sediment delivery rates, nutrient loading and pathogen transport in relation to grazing. In order to achieve these ends, 1) Baseline data are critical, and 2) data must be developed in a watershed and/or ecosystem approach (Rinne, 1988). For example, Rutt et al. (1993) developed a rapid assessment system that could predict (using only field data) the degree of impact on water quality. Such a tool for assessing and monitoring impacts in Minnesota would be useful and appropriate.

In the western United States, several grazing strategies have been employed to reduce the effect of grazing on riparian systems. Most agree with Myers and Swanson (1995), who indicate that deferred rotation grazing led to improvement of aquatic and riparian habitats, but that complete rest produced the most improvement. In the Midwest, managed rotational grazing has been adopted by a large number of dairy farmers, especially in Wisconsin. A controversy has developed because traditional best management practices, based on the experiences in the arid western United States, recommend that cows be excluded from the riparian zone. Exclusion of cows from the riparian zone is often unpopular with rotational graziers, because it is expensive and takes land out of production. However, managed rotational grazing effectively reduces the time cows spend in riparian areas and has been demonstrated to reduce the impact in and along streams in relation to continuous grazing (Sovell, 1997; Cox, 1998; Nerbonne, 1999; John Lyons, Wisconsin Department of Natural Resources, unpublished). Thus, research needs to be conducted to determine how to manage riparian areas so that forage can be utilized while minimizing the effects on water quality and fish and invertebrates.

6. How do the various impacts in #1 to #5 vary by species, operation, system type, management, geography, geology, watershed characteristics, and concentration of livestock facilities?

Overview of Minnesota hydrogeology

Soil and Geological Sediments

Minnesota has a wide diversity of soil and geological sediments. The primary focus in this section is the relative impact of these soils and sediments on surface and ground water pollution potentials. Pollution of ground water depends upon several factors (Knox and Moody, 1991), including depth to ground water, permeability and hydraulic properties of surficial soils and sediments, land management, and climatic factors. Major types of surficial soils and sediments in Minnesota include karst formations, coarse textured sands and outwash, fine textured silts and lake sediments, glacial tills, moraines, and peatlands (Fig. 3). Ground water pollution potentials are, in general, greater for the coarse textured sands and outwash or the karst formations than for other types of surficial soils and sediments. The fine textured silts, lake sediments, and glacial till soils tend to have poor internal drainage of water. As a result, they tend to have significant proportions of artificial drainage to remove ponded water and enhance agricultural productivity. Tile drainage water discharges to surface waters, so the fine textured silts, lake sediments, and glacial till soils have a potentially greater surface water quality impact than a ground water quality impact. Soils and sediments on moraines tend to have better internal drainage than the fine textured silts, lake sediments, and glacial till soils, and are generally located on steeper terrain, too. Depending upon site-specific characteristics, moraines have the potential to impact either surface water quality or ground water quality. Karst formations are similar to moraines in that they both have the potential to pollute either surface or ground water. Most of the karst formations are buried by a thin layer of fine textured loess, and are located on steep slopes. Thus, water runoff and erosion can be significant in the karst region, leading to potential impacts on surface water quality.

Precipitation and Runoff

Mean annual precipitation is highly variable in Minnesota (Fig. 4). The Red River basin receives from 19-26 inches, while the Minnesota River basin receives from 22-31 inches. The Upper Mississippi River receives from 23-30 inches, while the Lower Mississippi River receives from 30-33 inches. Average annual runoff rates vary with the precipitation patterns (Fig. 5). The Red River basin has average annual runoff rates of from 2-3 inches, while the Minnesota River basin has rates from 1-6 inches. The Upper Mississippi River has average annual rates of runoff ranging from nearly 4-7 inches, while the Lower Mississippi River has rates of from 7-8 inches.

Fig. 3: Surface Soil Properties-Summarized from Agroecoregions

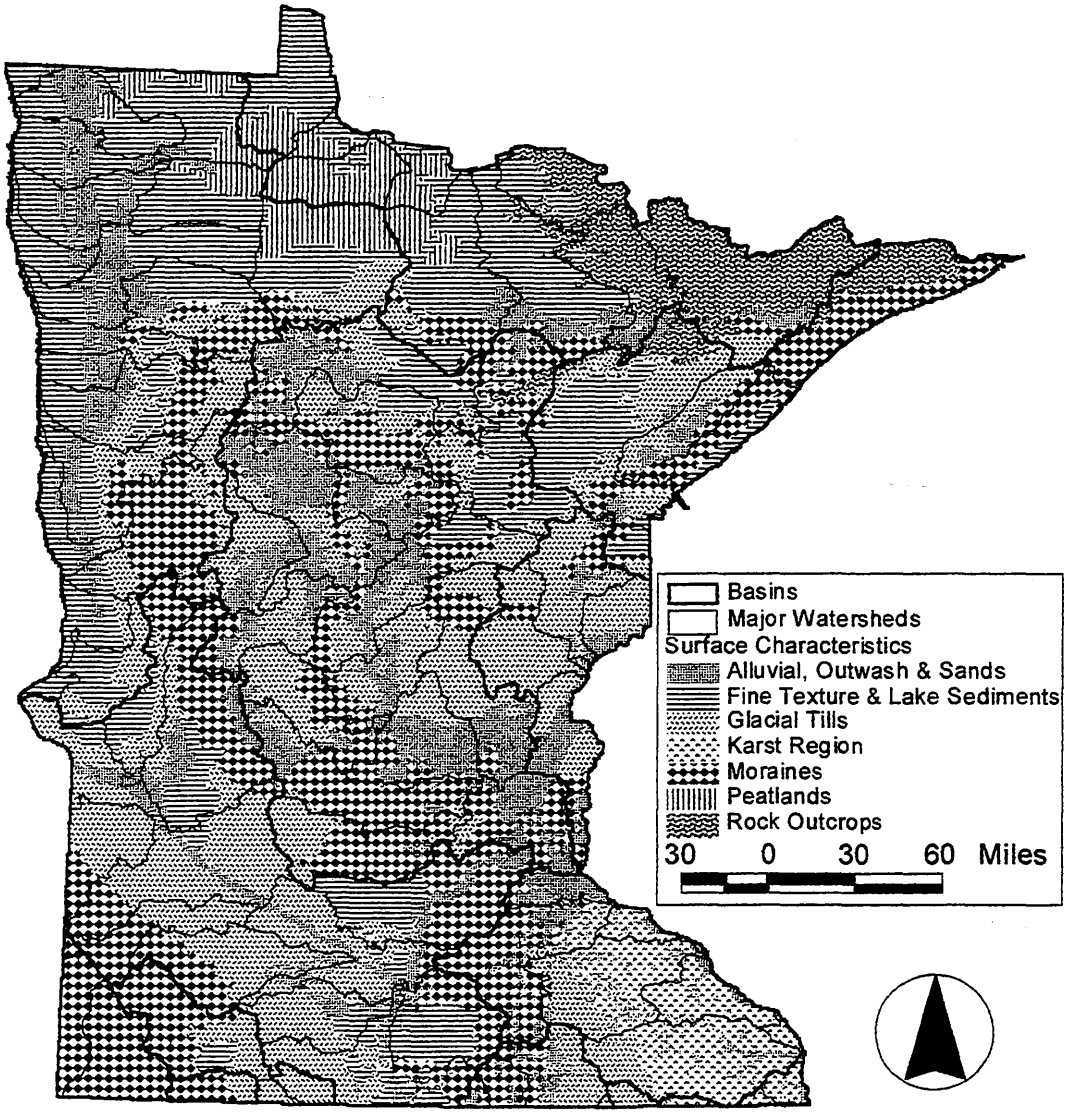


Fig. 4: Normal Annual Precipitation (1961-1990)

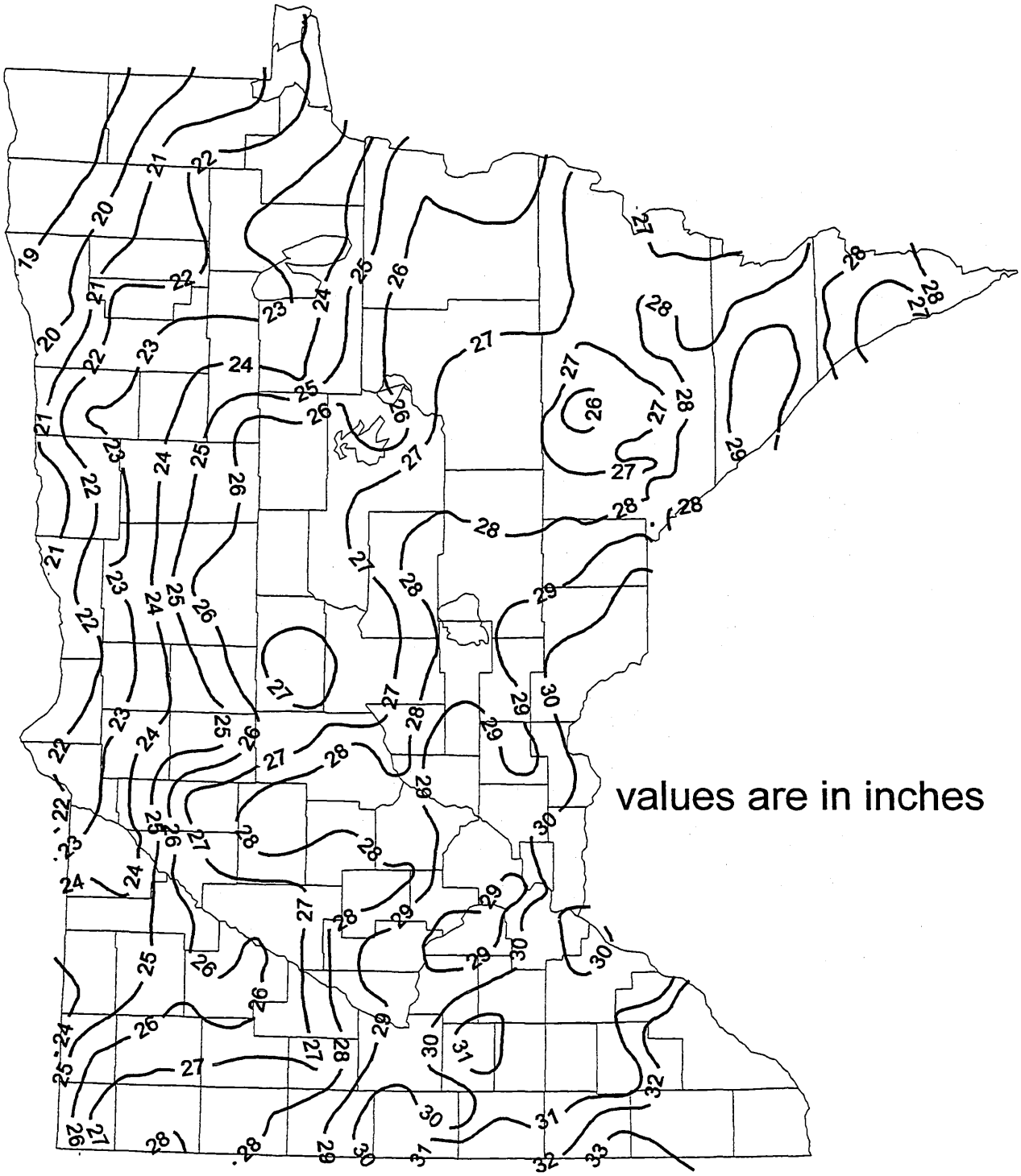
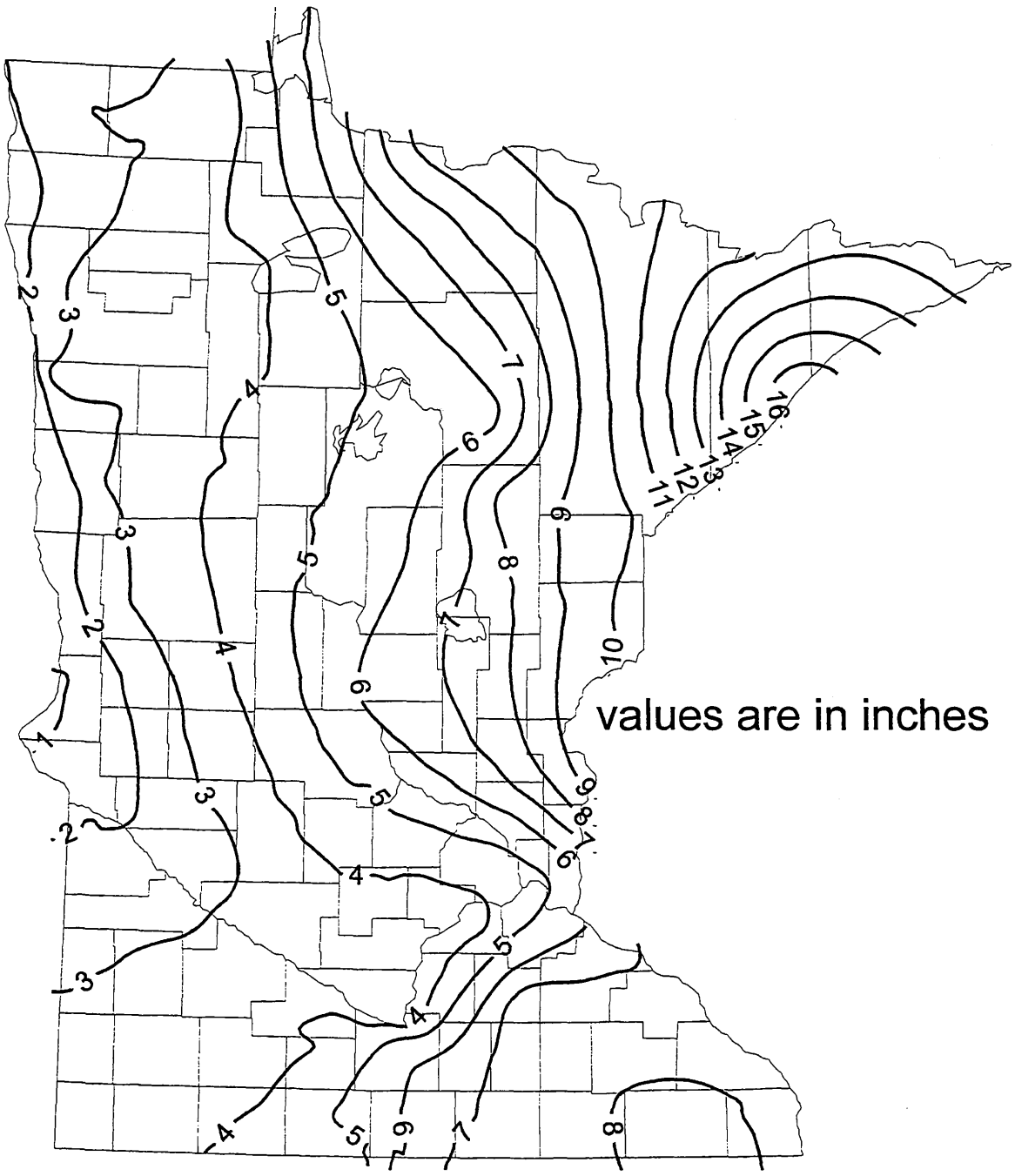


Fig. 5: Average Annual Runoff (1961-1990)



runoff derived from streamflow

Erosion Potential by Major Hydrologic Basin

Particulate phosphorus and biochemical oxygen demanding materials are primarily transported into surface waters by erosion. Water erosion potentials depend upon several factors, including the climate, soil erodibility, slope length and steepness, vegetative and residue cover, and other cultural practices. In general, water erosion rates for cultivated cropland are much greater than for forestland or pastureland (USDA-NRCS NRI, 1996). There is a wide range in annual erosion rates and land use patterns for the major basins in Minnesota (Table 28):

Table 28: USDA-NRCS National Resource Inventory Annual Water Erosion Rates (1992).

Hydrologic Basin	Cult. Cropland Acres (1000s)	Erosion (t/ac/yr)	Pastureland Acres (1000s)	Erosion (t/ac/yr)	Forestland Acres (1000s)	Erosion (t/ac/yr)	Total Erosion (millions of tons/yr)
Mississippi River Headwaters	630	1.9	450	0.1	3478	0.0	1.2
Upper Mississippi River	1958	2.9	629	0.3	697	0.0	5.9
Lower Mississippi River*	1948	4.9	331	0.9	541	0.0	9.8
St. Croix River*	255	3.1	301	0.2	1042	0.0	0.8
Upper Red River*	2443	1.4	266	0.1	464	0.0	3.4
Lower Red River*	2507	0.6	338	0.0	1620	0.0	1.5
Minnesota River*	6614	2.5	644	0.4	263	0.0	16.8

* Portions in Minnesota only

These erosion statistics show that cultivated cropland acreage is far greater in the Minnesota River basin than any other basin. Rates of erosion from the cultivated cropland in the Minnesota River basin average 2.5 t/ac/yr, lower than rates in the Lower Mississippi River (4.9 t/ac/yr) where very steep landscapes exist. Large acreages of pastureland exist both in the Mississippi River Headwaters and the Minnesota River basin, but rates of erosion on pastureland are much less than on cultivated cropland. The Mississippi River Headwaters has the greatest amount of forestland, and erosion rates on all forestland are negligible. Total erosion in the Minnesota River basin (16.8 million tons/yr) is nearly double the total erosion for the next most important basin, the Lower Mississippi River basin. The Lower Mississippi River basin has

nearly double the total erosion loss than the Red River basins or the Upper Mississippi River basin. The Minnesota portion of the St. Croix River basin generates very small quantities of soil erosion due to the small acreage in cultivated cropland. Only a small fraction (less than 5%) of erosion losses are transported from upland regions to the mouth of the major hydrologic basins. Most of the sediment and associated particulate phosphorus is redeposited at the base of hillslopes or in wetlands, ditches, and lakes upstream of the river mouth.

Overview of Water Quality in Minnesota

River Basins

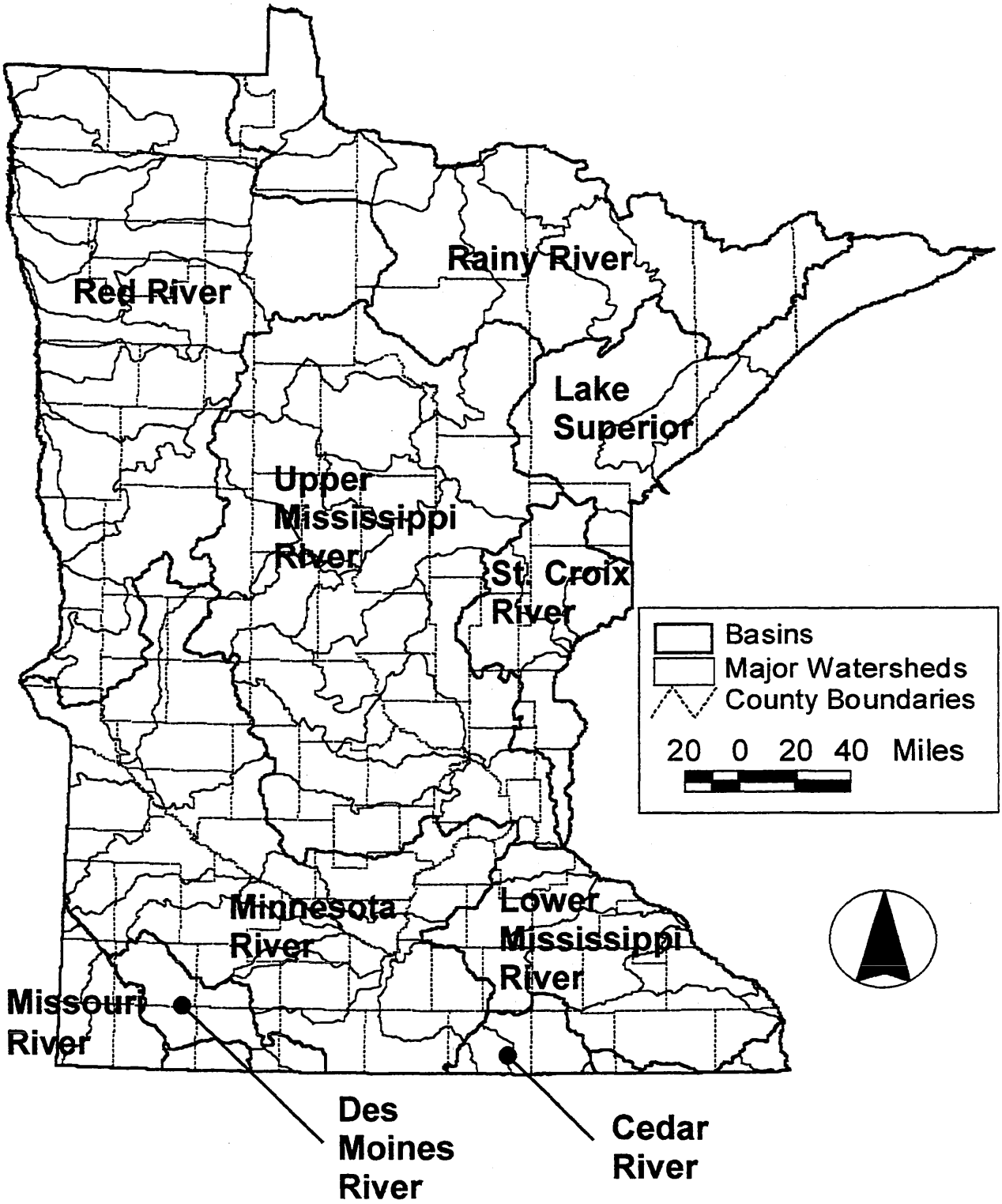
The major river basins in Minnesota that include intensive agricultural land uses are the Minnesota River basin, the Red River of the North basin, the Upper Mississippi River basin, and the Lower Mississippi River basin (Fig. 6). Each of these basins is sub-divided into major watersheds. For instance, the Minnesota River basin has 12 major watersheds.

The U.S. Geological Survey, the Minnesota Pollution Control Agency, and the Metropolitan Council have conducted extensive monitoring of surface water quality at or near the mouths of major watersheds for several decades. Datasets from 1968 to 1994 consisting of several samples per month for water quality monitoring at single sites near the mouths of major watersheds in Minnesota were obtained and used to produce maps of the percent of all water quality samples above or below critical values. For dissolved oxygen (DO) the critical value is 5 mg/L (the U.S. EPA water quality standard). This standard is violated when DO is less than 5 mg/L. The critical standard for fecal coliform is 200 Colony Forming Units (CFU)/100 mL, and values greater than this are worse than values below it. There are no water quality standards for nonpoint sources of total phosphorus or biochemical oxygen demand in surface waters. To illustrate trends in water quality degradation from total phosphorus we have chosen to report the percent of samples that exceed a concentration of 0.25 mg/L total phosphorus. For BOD the percent of samples exceeding a concentration of 5 mg/L were identified. Maps were produced showing the extent to which water quality samples did not meet the critical values specified above. Data were processed only for the Minnesota, Upper Mississippi, Lower Mississippi, the St. Croix, and Red River basins. The results were divided into the following categories:

Table 29: Percent of Water Quality Samples
Not Meeting Critical Value, and Extent of Pollution

Extent of Pollution	% Not Meeting Critical Value For Water Quality
Low	0-10%
Medium	10-20%
High	20-30%
Very High	30-50%
Extreme	50-70%

Fig. 6: Major River Basins in Minnesota



The greatest number of water quality violations (high, very high, or extreme pollution extent) for BOD occurred in southern portions of the Upper Mississippi River basin, most of the Minnesota River basin, the scattered portions of the Red River basin, and western or central portions of the Lower Mississippi River basin (Fig. 7). The greatest number of water quality violations for fecal coliform bacteria occurred in the Lower Mississippi River basin, the Minnesota River basin, the southern portion of the Upper Mississippi River basin, central portions of the Red River, and some of the St. Croix basin (Fig. 8). The greatest number of water quality violations for dissolved oxygen occurred in the North Fork of the Crow River of the Upper Mississippi River basin, and the Mustinka River and the Upper and Lower Red Lake River portions of the Red River basin (Fig. 9). Total phosphorus levels were worst in the Lower Mississippi River basin, the central and eastern portions of the Minnesota River basin, the southern portions of the Upper Mississippi River basin, and scattered portions of the Red River with more severe problems in the northern half of the basin (Fig. 10). The most severe overall degradation of surface water quality tends to occur mostly in the fine textured morainal, till, and karst region soils (Fig. 3) having runoff depths of 3 inches or more (Fig. 5). These areas correspond with the Western Corn Belt Plains and North Central Hardwood Forests ecoregions discussed below, and water quality trends summarized above are consistent with those reported for Minnesota ecoregions by McCollor and Heiskary (1993). Fecal bacteria are also a severe problem in much of the Red River Valley ecoregion, where shallow water tables and poorly drained soils cause individual sewage treatment systems to perform poorly.

It should be remembered that evaluating pollutant concentrations is only one approach for determining the level of impairment for rivers. Other methods involve estimating the load (total mass per year) of pollutants carried by the river, using measurements of both concentration and flow. Loads are a better indicator of downstream impacts than concentrations. In the Minnesota River basin, spatial patterns in loads of phosphorus are quite different from the spatial patterns in phosphorus concentrations. The eastern portion of the Minnesota River basin carries two-thirds of the total phosphorus loads in the entire basin (Mulla and Mallawatantri, 1997).

Lakes

Heiskary and Wilson (1989) summarized the results of 10 years of lake water quality (Figs. 11-12) monitoring data (1400 lakes). Water quality characteristics were strongly related to ecoregion boundaries (Fig. 13, Table 30) and land use patterns. Characteristics included total phosphorus (a measure of nutrient enrichment), chlorophyll a (a measure of algal biomass), and Secchi disk depth visibility (a measure of lake clarity). Water quality was best in the Northern Lakes and Forests ecoregion, which had 75% forest cover. Next best was the North Central Hardwood Forests, with roughly half of the land in cultivation, and 35% in forest or pasture. The Twin Cities Metropolitan area is included in the North Central Hardwood Forests lake water quality database. Water quality of lakes was quite poor in the Western Corn Belt Plains, where 80% of the land is cultivated. The worst lake water quality was found in the Northern Glaciated Plains, where 84% of the land is cultivated, and mean annual precipitation is significantly less than in the Western Corn Belt Plains.

Fig. 7: Biochemical Oxygen Demand

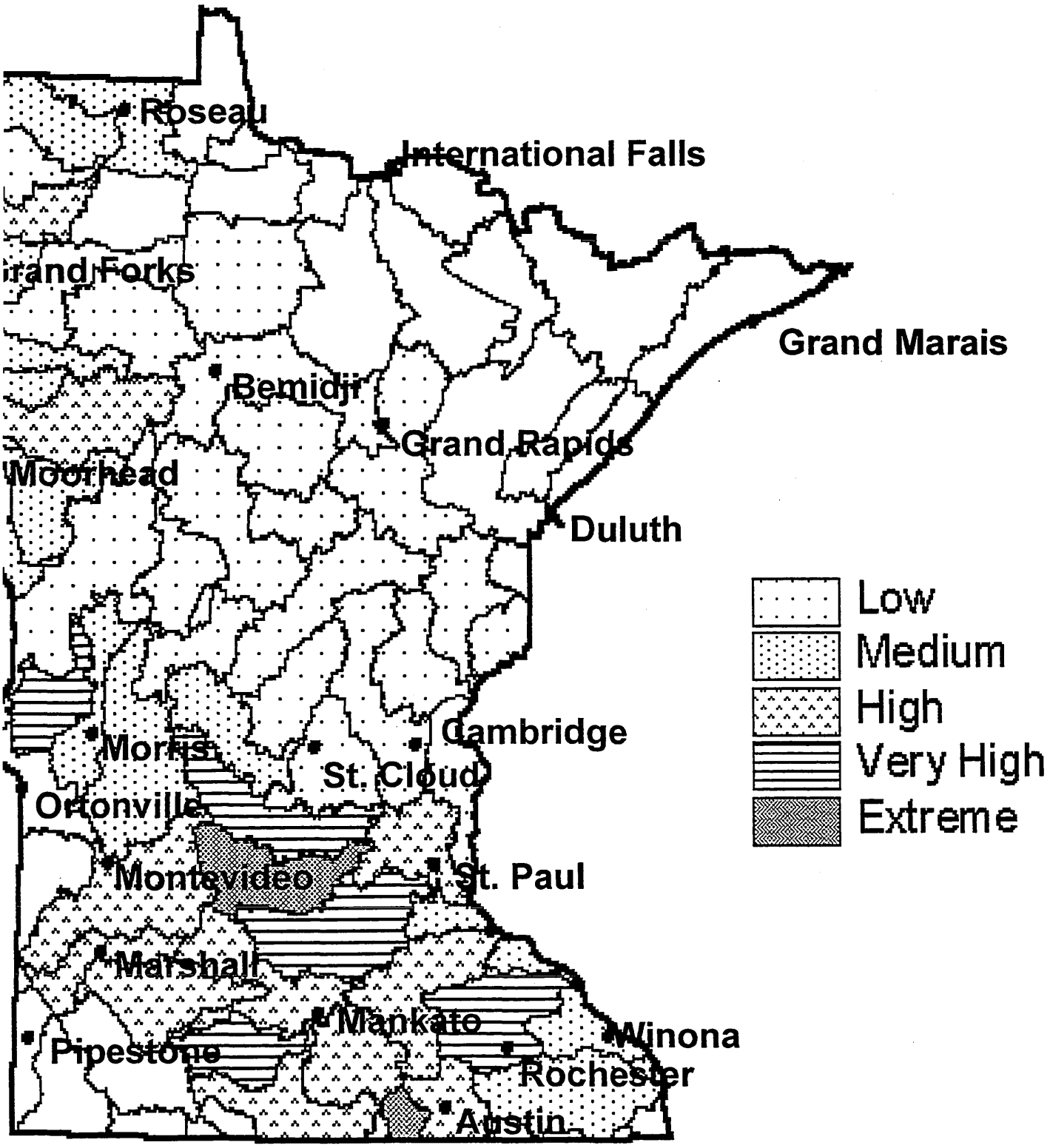


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Fig. 8: Fecal Coliform Bacteria

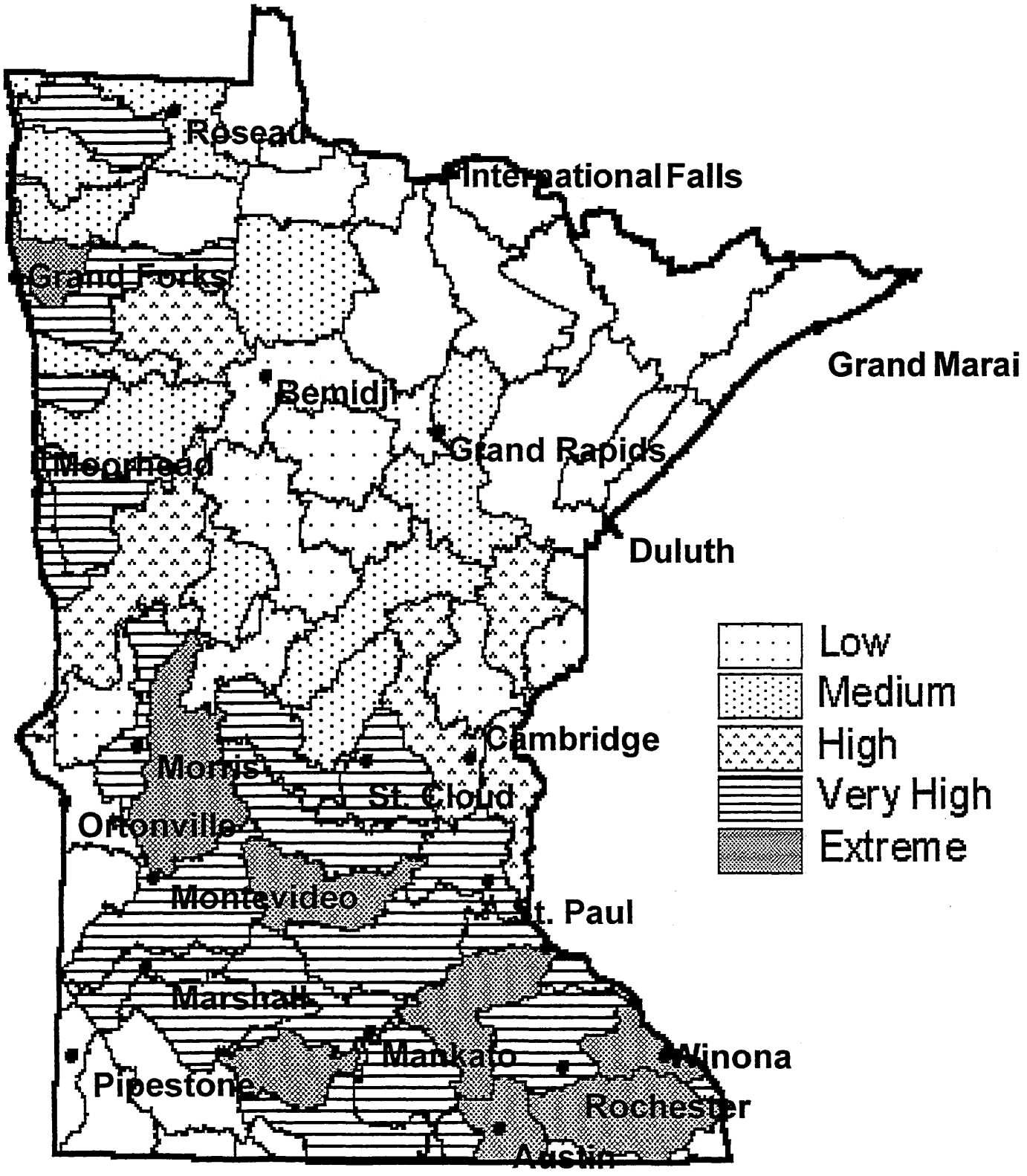

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Fig. 9: Dissolved Oxygen

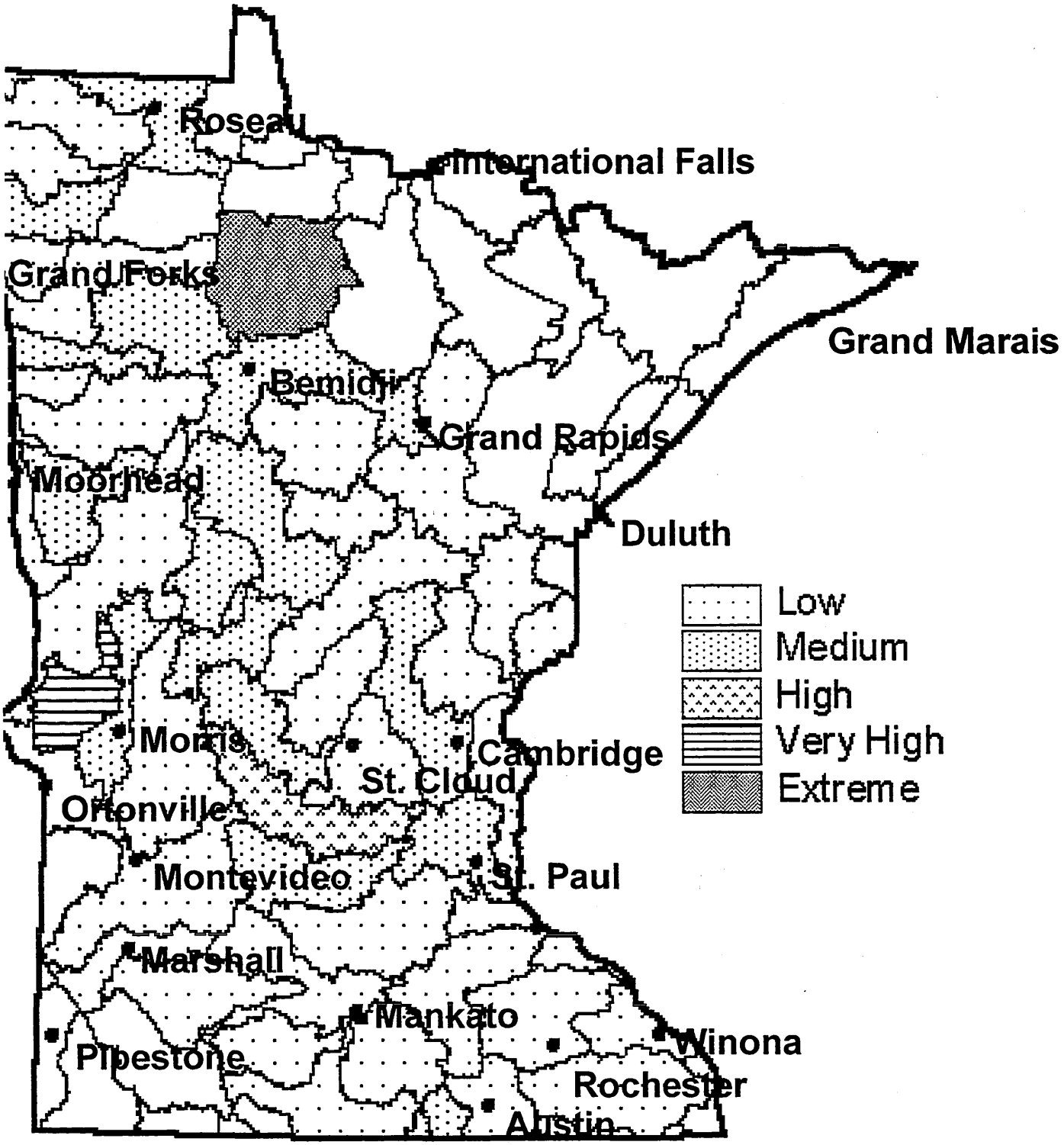

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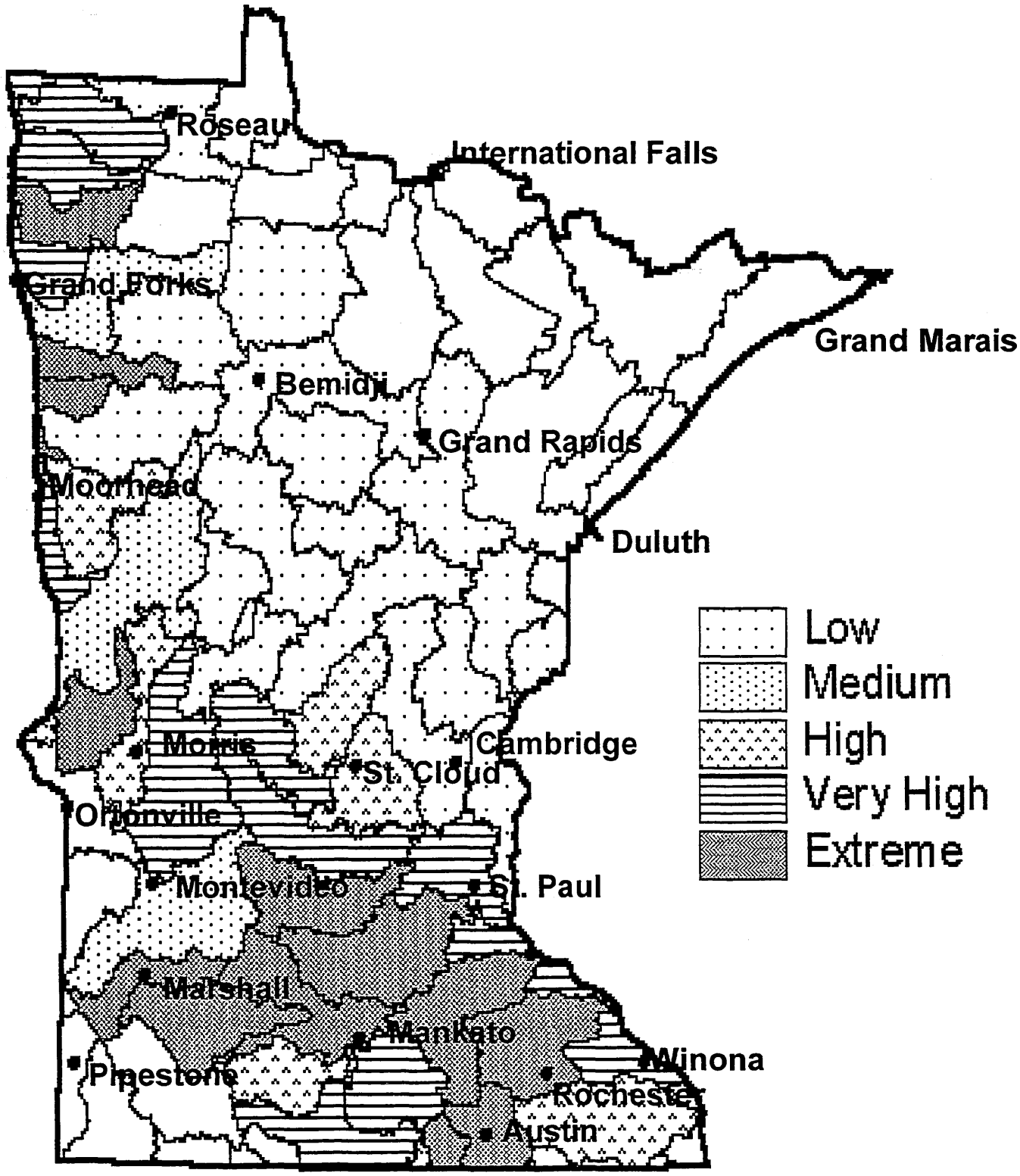
Fig. 10: Total Phosphorus



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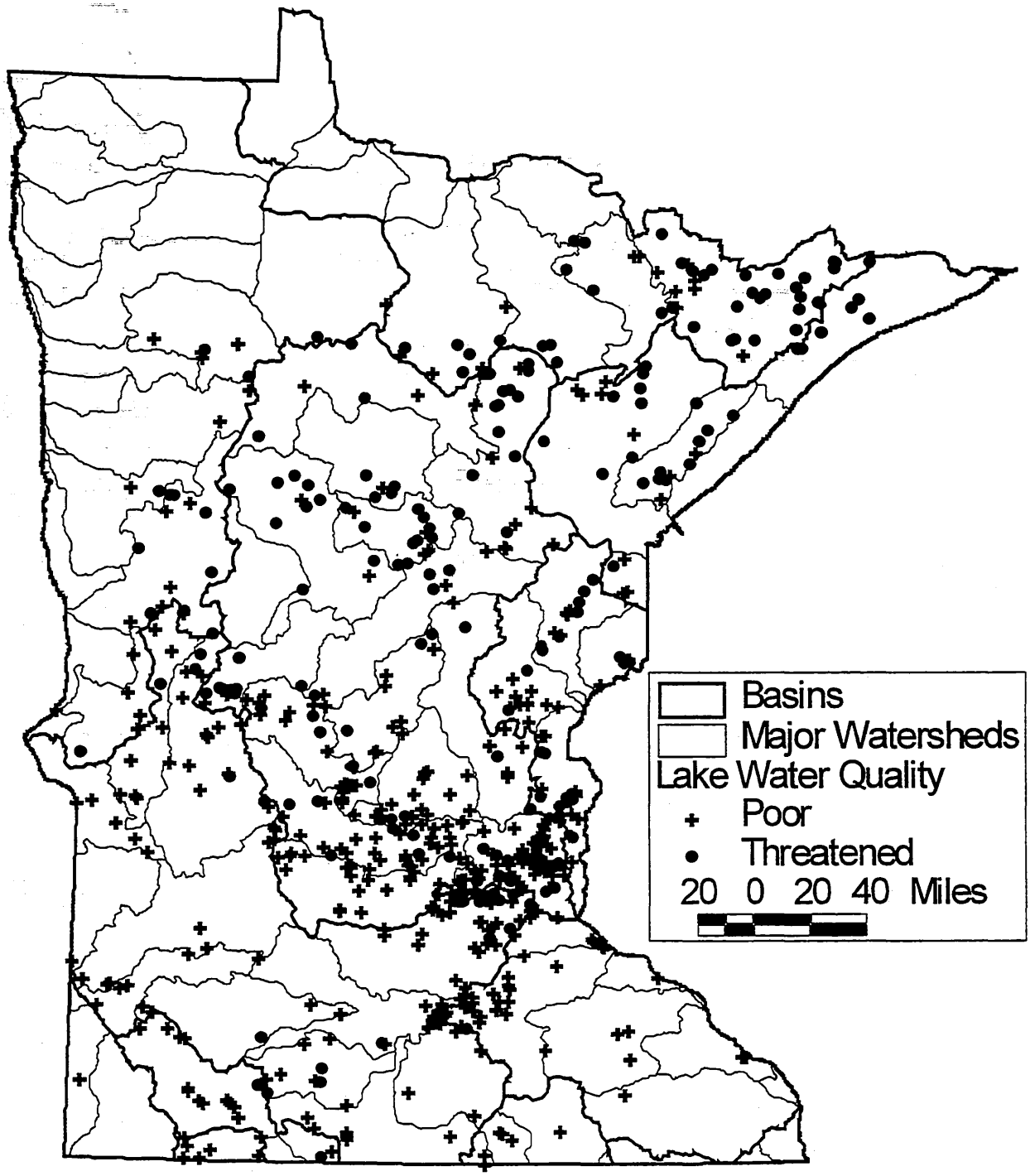
For comparison with ecoregion classification of lake water quality data, the Metropolitan Council Environmental Services database on Twin Cities Metropolitan area lake water quality monitoring was separately analysed. Results showed that lakes in the Twin Cities Metropolitan area tend to have water quality levels between the levels for lakes in the North Central Hardwood Forests ecoregion and the Western Corn Belt Plains ecoregion. The overall spatial pattern of lakes with poor water quality (Fig. 11) coincides closely with fine textured soils on glacial moraines (Fig. 3) in the southern half of Minnesota.

Table 30: Lake Water Quality Mean Values for EPA Aquatic Ecoregions and Twin Cities Metro Area

Region	Total Phosphorus	Chlorophyll a	Secchi Disk
	----------ug/L----------		(ft)
Northern Lakes and Forests	14-27	<10	8-15
North Central Hardwood Forests	23-50	5-22	5-10
Western Corn Belt Plains	65-150	30-80	2-3
Northern Glaciated Plains	130-250	30-55	1-3
Metro Twin Cities	66	25	6

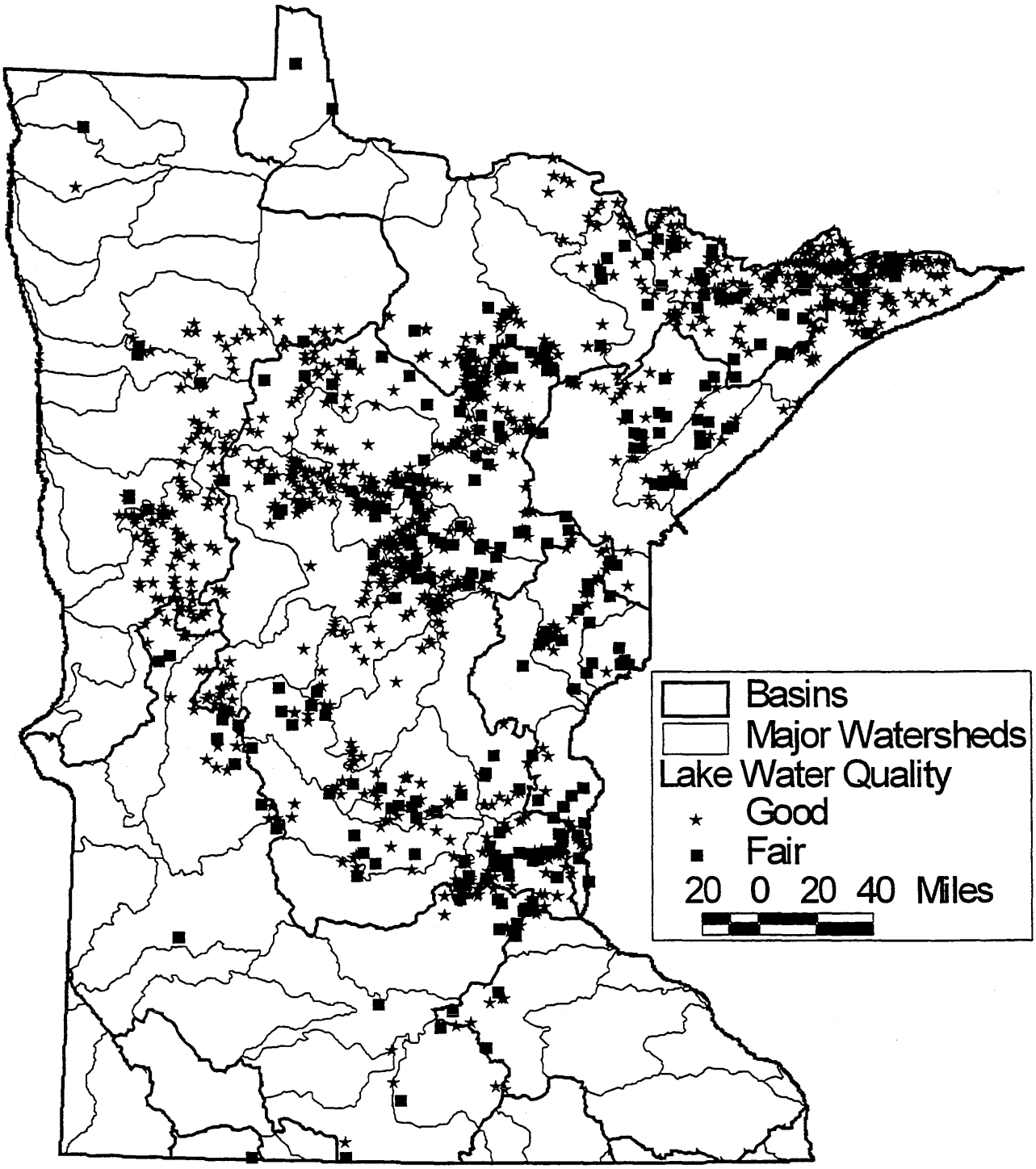
Heiskary and Wilson (1994) summarized the impact of various land uses on phosphorus export to lakes in Minnesota. Cultivated agricultural lands typically have annual phosphorus losses to lakes of from 0.18 to 0.54 lb P/ac. Pastured lands have losses of 0.18 to 0.36 lb P/ac, with the lower values being for grassland and the higher values being for animal grazing. Urban areas have losses of 0.45 to 1.11 lb P/ac, which are higher than the values for cultivated land because urban areas tend to have runoff from impervious surfaces transported into storm sewer systems. Urban phosphorus losses can include losses from septic systems, but do not generally account for losses to wastewater treatment plants. Forests and wetlands have very low phosphorus losses ranging from 0.09 to 0.13 lb P/ac. Feedlots without containment of runoff have extremely high losses ranging from 134 to 401 lb P/ac, but under normal circumstances the coefficients for feedlots are typically from 1.0 to 2.23 lb P/ac. The actual impact of phosphorus losses to lakes depends upon these phosphorus losses, as well as factors such as watershed area, hydrologic and climatic factors, lake volume, population density, areas of the watershed in various land uses, and livestock animal density.

Fig. 11: Assessment of Lake Water Quality Conditions: Threatened and Poor Quality



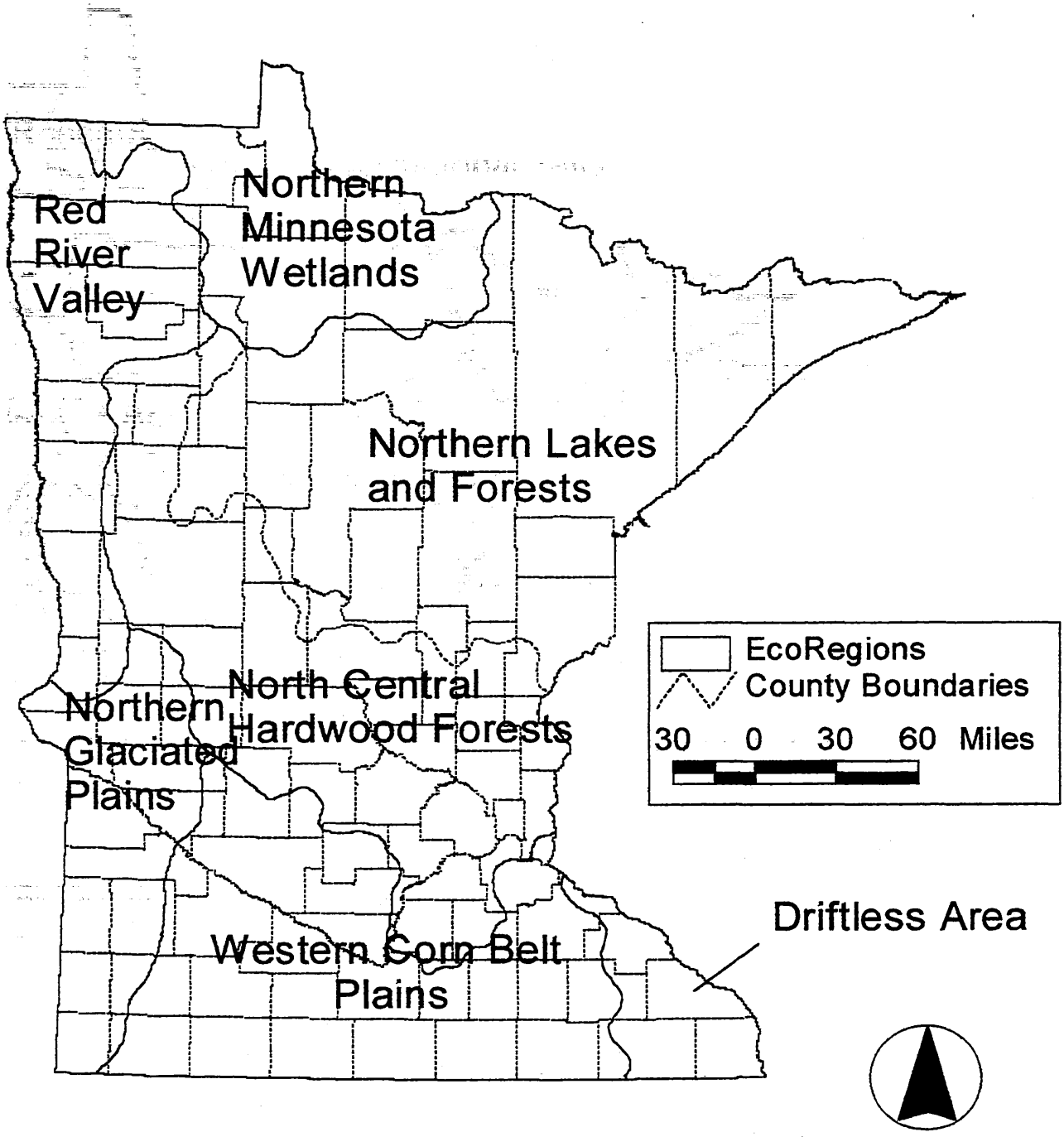
* Assessment completed by the Minnesota Pollution Control Agency

Fig. 12: Assessment of Lake Water Quality Conditions: Good or Fair Condition



* Assessment completed by the Minnesota Pollution Control Agency

Fig. 13: Minnesota's Seven Ecoregions



Ground Water

Ground water monitoring has been conducted since the 1970s by several agencies in Minnesota, including the Minnesota Department of Health, the Minnesota Pollution Control Agency, and Minnesota counties. The ANitrate-Nitrogen in Minnesota Groundwater@ map (Fig. 14) shows the results for more than 30,000 drinking water wells in Minnesota from the following databases:

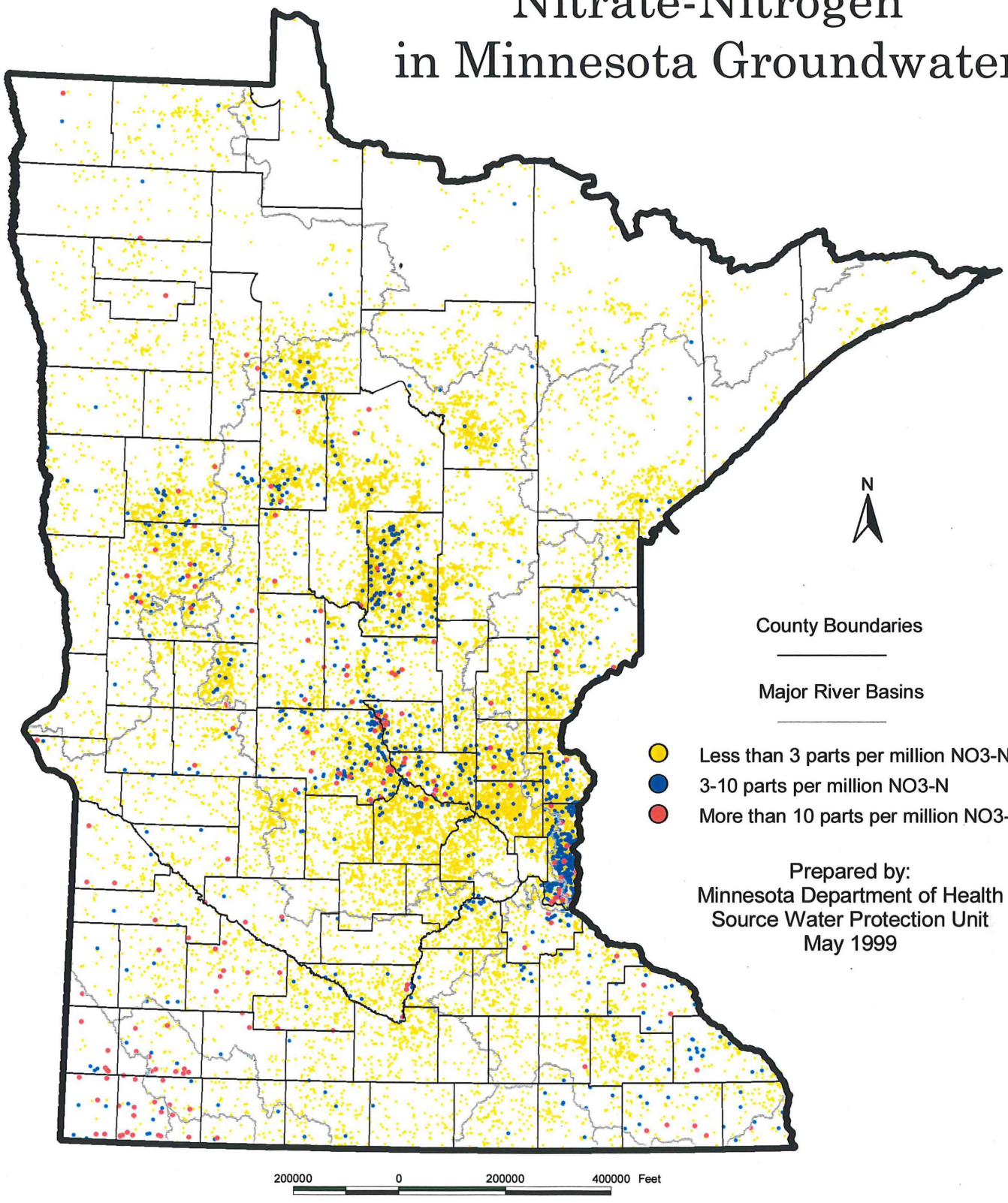
- The County Well Index (CWI) and Minnesota Department of Health (MDH) Well Management (28,000 wells),
- The MDH Public Water Supply (1000 wells),
- The Private Well Survey conducted by the Centers for Disease Control and Prevention and the MDH (750 wells), and
- The Minnesota Pollution Control Agency (950 wells) Ground Water Monitoring and Assessment Program (GWMAP).

There is an overall bias in most of these databases toward good water quality since most analytical results for nitrate in the existing databases were collected from wells constructed since the Water Well Construction Code became effective in 1974. Drinking water wells exceed the maximum contaminant level (MCL) for nitrate-nitrogen of 10 mg/L in almost every county (Fig. 14), but the majority of the contamination problems occur in five cluster areas.

The first cluster is the heavily populated region of Washington county overlain with coarse textured soils (Fig. 3). Primary aquifers in this region include the Prairie du Chien and St. Peter aquifers. The second includes wells overlain by coarse textured soils (Fig. 3) along the Upper Mississippi River in Stearns, Sherburne, Benton, Morrison, Crow Wing, and Hubbard counties. The primary aquifers here would involve surficial and buried drift, as well as deeper Precambrian igneous rocks. The third includes wells in the moraines of Otter Tail and Becker counties. The primary aquifers here involve surficial and buried drift aquifers. The fourth includes wells in the karst region of southeastern Minnesota (Fig. 3).

A multitude of aquifers supply water to southeastern Minnesota, including the Upper Carbonate, St. Peter, Prairie du Chien-Jordan, and Ironton-Galesville aquifers. The fifth includes wells in the tills and moraines of southwestern Minnesota (Fig. 3). Primary aquifers in southwestern Minnesota include very vulnerable shallow alluvial sand aquifers, Cretaceous sandstone and shale aquifers, and the deep fractured Sioux Quartzite aquifer. The highest concentrations of nitrate-N (Knox and Moody, 1991; Kroening and Andrews, 1997) tend to occur in the Sioux Quartzite (25% of samples exceed 45 mg/L nitrate-N). Nitrate levels are also elevated in Surficial Drift aquifers (25% exceed 10 mg/L), especially the Anoka Sand Plains area, and the Upper Carbonate (25% exceed 3 mg/L) aquifers.

Nitrate-Nitrogen in Minnesota Groundwater



Data sources include:
- County Well Index and Minnesota Department of Health Well Management - average values 1973-1999
- Minnesota Department of Health Public Water Supply - average values to 1999
- Private Well Survey by U. S. Centers for Disease Control and Minnesota Department of Health 1993-1995
- Minnesota Pollution Control Agency Ground Water Monitoring and Assessment Program 1998

Areas which are not geologically susceptible to ground water contamination include areas where there are confining aquitards which limit the movement of nitrate- or pathogen-contaminated surface water from moving down into an aquifer. However, where those aquitards are breached, contaminated water can impact the drinking water aquifer(s) as well. (Aquitards can be breached where unused and unsealed wells or wells in disrepair connect surface water to a deeper aquifer.) Therefore, sealing unused, unsealed wells is very important in all areas of the state, and especially on land parcels in the immediate vicinity of animal feedlots and cropland. Also, many aquitards are of limited spatial extent, or have variable thickness, and are too thin in some places to provide good protection for a lower aquifer.

Most rural residents, and therefore most residents living in agricultural areas where impacts could happen first, have their own wells. Many well users never test their well water; if they do test the water, it may be only once in many years; and it is extremely rare for a well owner to test their water as much as once a year. (A well installer is required to test the well before it is put into production; however, this has only been a requirement for new wells since 1975. There are a great many wells older which are still in use.) Therefore, if someone's well drew in contaminated water, but the problem did not change the color, odor, taste, etc., it is unlikely the well owner would know about the contamination. It cannot be assumed that most rural residents have any water treatment system on their well water. Therefore, it is important to protect the ground water quality from contamination in the first place.

The vulnerability of ground water to contamination can be estimated using the *County Geologic Atlas* series, published by the Minnesota Geological Survey (MGS). This series covers many counties, including the seven-county Twin Cities metropolitan area, most of the counties in the karst area of southeastern Minnesota, and various other counties. Producing this series is an on-going effort, and additional counties will be added with time. This series includes maps such as: bedrock geology; surficial geology (mostly, glacial deposits); depth to bedrock; geologic resources; sinkholes and sinkhole (development) probability; aquifer susceptibility to pollution; springsheds; etc.

Sensitive Ground Water Areas

Massie et al. (1993) stated that the best location for a farmstead would involve adequate space on flat, well-drained soil, with a deep water table, no karst or sandy soil, and far from surface waters. In Minnesota, there are certain regions (karst region, central sands region) which are vulnerable to ground water pollution. A few studies of the pollution potential for ground water from animal manure have been conducted in these regions.

Karst

The results of a series of studies conducted by Prof. Alexander at the University of Minnesota and numerous other researchers have repeatedly demonstrated the direct links from activities on the land surface to the ground water in the karst region of southeastern Minnesota. The most significant results showed how quickly the tracers travelled from the surface stream, into the ground water, and were detected in wells and springs miles away, even traveling under

surface-water drainage divides (Mohring and Alexander, 1986). This means all land uses in the karst area must carefully prevent the release of any pollution which could degrade the quality of ground water. Due to the demonstrated complexity of the ground water systems, it is impossible to predict which drinking water wells are likely to be affected if a contaminant is spilled or released in the karst area. Therefore, ground water in much of the karst area is at high risk for contamination from wastewater holding structures (such as lagoons, basins, pits, etc.) that leak or collapse into sinkholes, because any leakage could quickly contaminate the ground water and someone's drinking water, yet usually without being detected.

Alexander et al. (1993) reviewed the collapse of a municipal waste water treatment plant (WWTP) in the karst terrain of southeastern Minnesota. In 1992 the Bellchester WWTP lost 2.3 million gallons of partially treated waste having 18mg/L of COD, 370 CFU/100 mL of fecal coliform, 1.7 mg/L of nitrate-N, and 0.3 mg/L of ammonia. Three other WWTP failures have occurred due to instability of the karst, and numerous animal waste lagoons are located in similar terrain.

Munyankusi et al. (1998) showed that fall or winter surface applications of manure in karst terrain increased water infiltration compared to a no manure treatment. Over 60% of the infiltration occurred during the non-growing season (Nov.-April). Leaching of N was significantly greater for the fall manure application (46 lb/ac) than the winter manure application (40 lb/ac), and both were significantly greater than the no manure application (33 lb/ac), with most of the leaching losses occurring during the non-growing season.

Sand Plains and Outwash

Ruhl (1987) found that roughly 20% of ground water wells in Minnesota on coarse irrigated sands exceeded the 10 mg/L drinking water MCL. Ground water below non-irrigated sands had much lower nitrate-N levels (5.4 mg/L vs 17 mg/L).

Komor and Anderson (1993) studied nitrate-N isotopic dilutions in 51 ground water wells beneath various land uses in the Anoka sand plains region. According to Ruhl (1987), 20% of the ground water wells in this region exceed the 10 mg/L drinking water limit. Diagnostic levels of nitrate-N isotopic enrichment are unique for nitrogen from manure, organic matter, and fertilizer sources. Nitrate-N concentrations in natural undeveloped areas averaged 4 mg/L, while concentrations for wells near feedlots, irrigated fields, and non-irrigated fields averaged from 13-16 mg/L. Concentrations for wells affected only by septic systems averaged 8 mg/L. Evidence from nitrate-N isotopic enrichment was found for nitrogen contamination of ground water wells by animal waste from feedlots and by fertilizer. Quality of ground water was poorer under feedlots than any other land use, with seriously elevated concentrations of nitrate-N, ammonium-N, very high specific conductivity, and very low dissolved oxygen levels.

Komor (1997) used isotopic boron enrichment levels to study sources of nitrate pollution of ground water in the Anoka Sand Plains. Manure is enriched in boron, and isotopic boron enrichment of manure from hogs (7.2 to11.2%), cattle (22 to 24%), and N fertilizers (-2 to 0.7%)

are all distinctly different. Nitrate levels in ground water wells beneath hog and cattle feedlots, and for cultivated fertilized fields and residential yards with septic tanks were above the drinking water limit. Nitrate levels for natural woods and cultivated fields receiving hog manure were below the drinking water limit. Isotopic enrichment in ground water near a hog feedlot and near cultivated fields receiving hog manure were consistent with isotopic levels in hog manure.

van Beek and Hettinga (1989) discovered that elevated concentrations of nitrate-N in liquid hog manure leaching through coarse sandy soils in the Netherlands cause oxidation of iron-sulfides in the ground water. The iron sulfides contain elevated concentrations of heavy metals, which are released into ground water upon oxidation. Elevated concentrations of nickel, cobalt, iron, and arsenic were measured in ground water beneath land receiving high rates of liquid hog manure. While the likely source of the heavy metals is oxidation of heavy metal bearing iron sulfides, the release of heavy metals from hog manure was not completely ruled out.

Overview of Animal Operations in Minnesota

Some of the most controversial issues involving animal agriculture revolve around the growing size of feedlots and the increasing density of animal operations. In this section, we review the literature to identify how animal density and feedlot size affect surface and ground water quality.

Animal Population Densities

Paik et al. (1996) describe the limits (based on N content of manure) that European nations have placed on the maximum number of animals per acre (Table 31):

Table 31: European Limits on Animal Density and Cropland Density.

Animal	Maximum Animal Density	Minimum Cropland Density
	----Animals/ac----	----ac/animal-----
Dairy Cow	0.8	1.2
Beef Cow	1.6	0.6
Pig	6.5	0.15
Turkey	40.5	0.02
Laying Hen	53.8	0.02

Montgomery and Legg (1993) summarized county distributions of animal density and nutrient content of manure produced in Minnesota. In what follows below, we follow their approach, using recently updated animal population figures.

The National Agricultural Statistical Service provides regular and accurate data for the number of cattle, hogs, chicken broilers, and turkeys in Minnesota counties. These data for 1997 were divided by the number of acres in each county to estimate county-wide average acres of

land per animal. In general, one of the main reasons why water quality can become degraded from animal operations is that there is not enough land for spreading of the manure produced by livestock.

Land available for spreading cattle and cow manure (Fig. 15) is most limited (5-11 acres per animal) in four regions of Minnesota, namely; the southeastern, southwestern, and west central, and central portions. Dairy cows predominate in southeastern and central Minnesota, especially Stearns, Otter Tail, Morrison, Winona, and Goodhue counties. Large numbers of dairy cows also occur in Fillmore, Wabasha, Carver, Wright, and Todd counties. Beef cows predominate in southeast, central, west central, southwest, and east central Minnesota. Counties with large populations of beef cows include Fillmore, Otter Tail, Houston, Olmstead, Cass, and Beltrami. According to Paik et al. (1996), one cropland acre per cow is about the critical value in much of Europe for manure spreading. County-wide averages in Minnesota are five to ten times better than this critical value, meaning that adequate land is available for manure spreading in most cases.

Land available for spreading hog manure (Fig. 16) is most limited (1-4 acres per animal) in much of south central Minnesota. The top five hog producing counties in 1997 were Martin, Blue Earth, Brown, Nicollet, and Renville. The worst county-wide cropland acreage values per hog in Minnesota are from 6 to 27 times better than the critical values used in Europe (Table 31).

Land available for spreading chicken manure (Fig. 17) is most limited in central and southeastern Minnesota. Chicken broiler production is greatest in Morrison, Stearns, and Benton counties. County-wide cropland acreages per broiler are quite a bit greater than the minimum values being used in Europe (Table 31).

Land available for spreading turkey manure (Fig. 18) is most limited in Kandiyohi, Meeker, Stearns, Morrison, and Todd counties. County-wide cropland acreages per turkey are about 10 times greater than the European limits (Table 31). Due to privacy concerns, not all counties report turkey populations. Some of the counties in central and south central Minnesota reporting no data could have very high turkey populations in a few animal operations.

The key question that remains to be answered is whether or not there is a general similarity between the patterns in county-wide animal densities and spatial patterns in water quality degradation for ground water, surface water, and lakes. The analysis which follows must be considered a preliminary and very qualitative step towards answering this question. Kellog and Lander (1999) conducted a nationwide study of the potential for surface water quality degradation arising from nutrients in animal manure. They estimated the amount of nutrients produced in manure, the applications of fertilizers, and the uptake requirments of crops to identify areas where manure inputs had a high potential to degrade surface water quality. Their nationwide pollution potential map shows large areas of central, southeastern, and southwestern Minnesota surface waters to be at risk from phosphorus in manure. The Minnesota River basin was not considered a high risk (Fig. 19). No information on actual water quality degradation patterns were considered by Kellog and Lander (1999).

Fig. 15: County Acres Per Number of Cattle

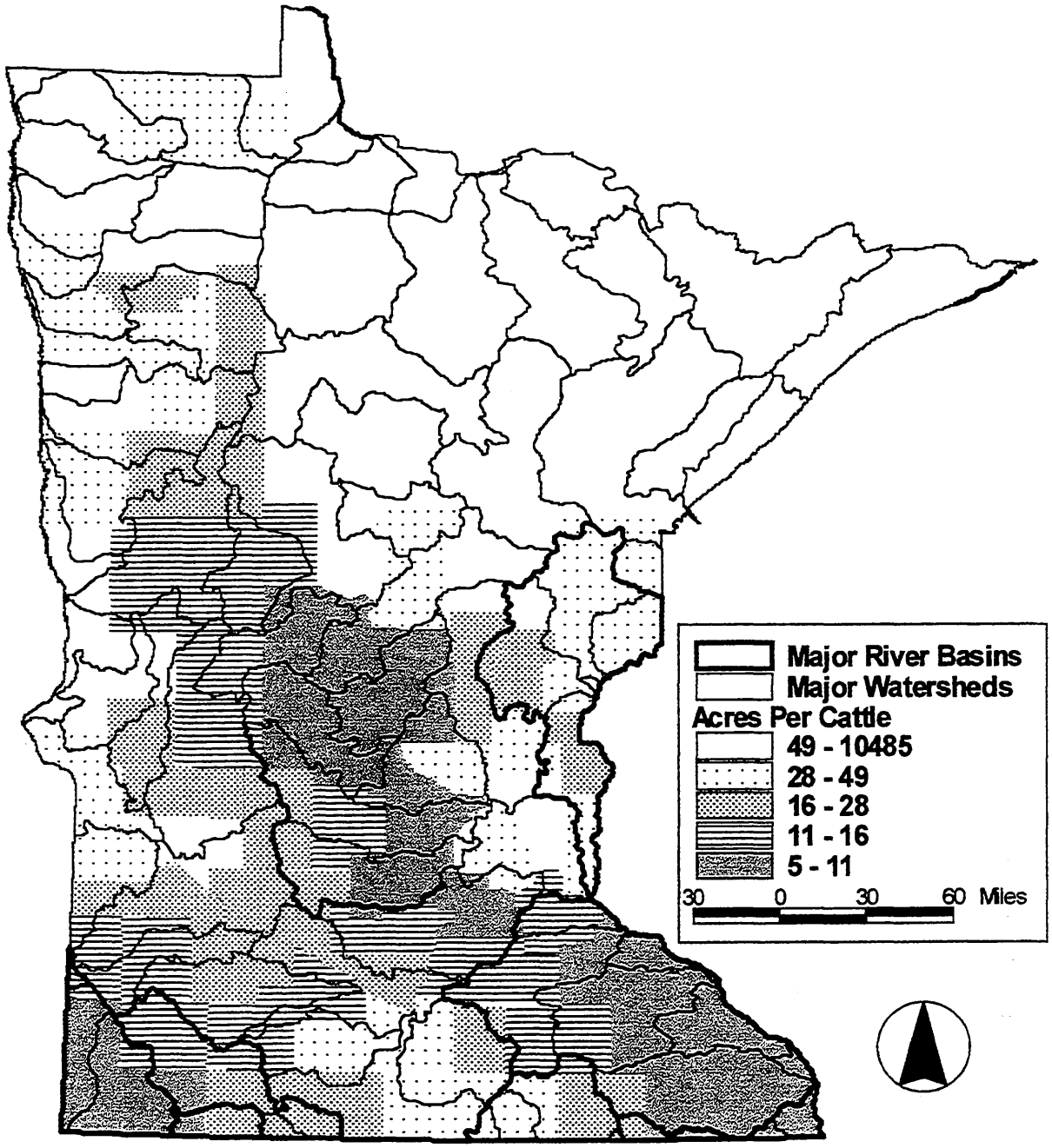


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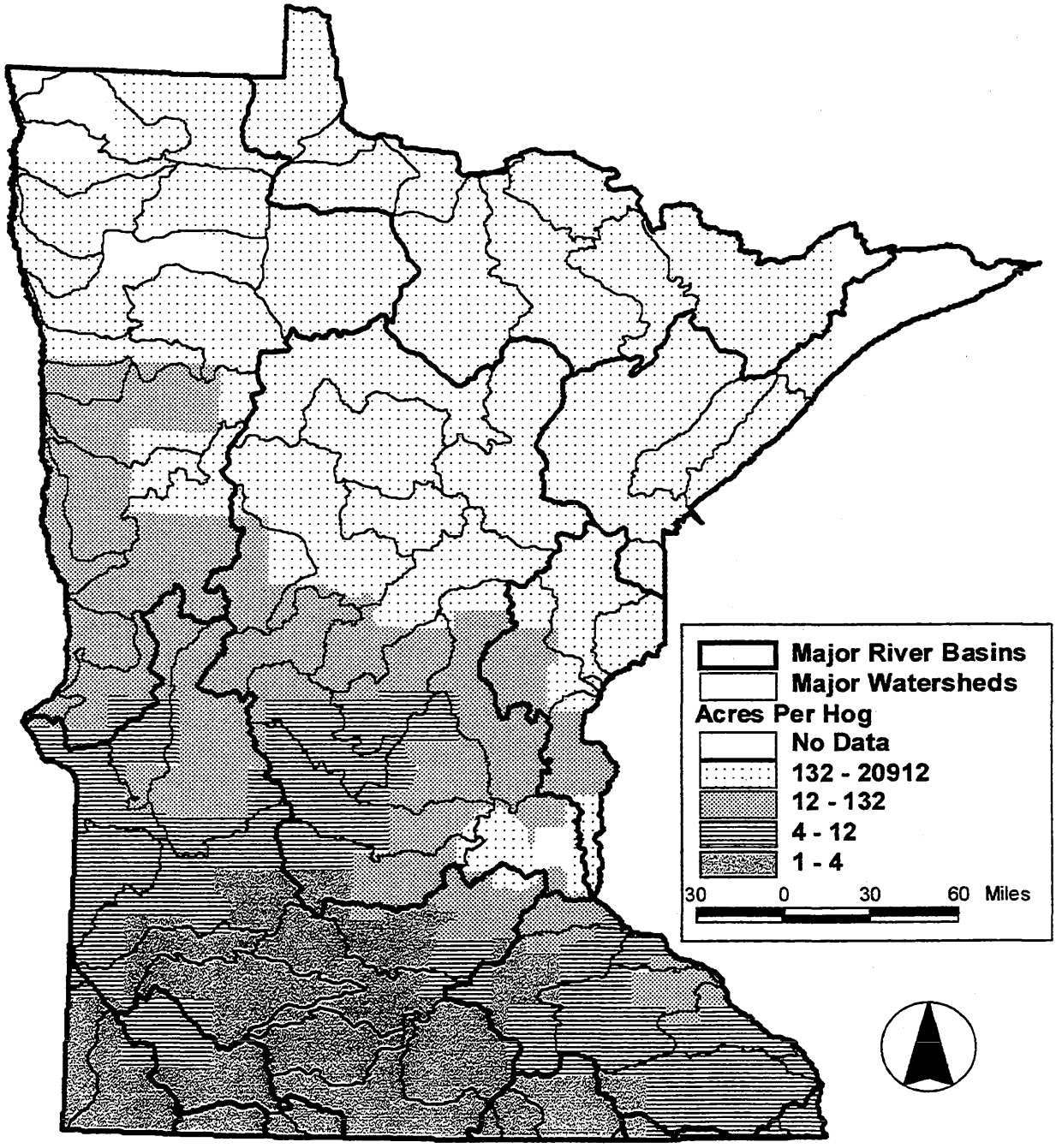
Fig. 16: County Acres Per Number of Hogs



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1999

Fig. 17: County Acres Per Number of Chickens

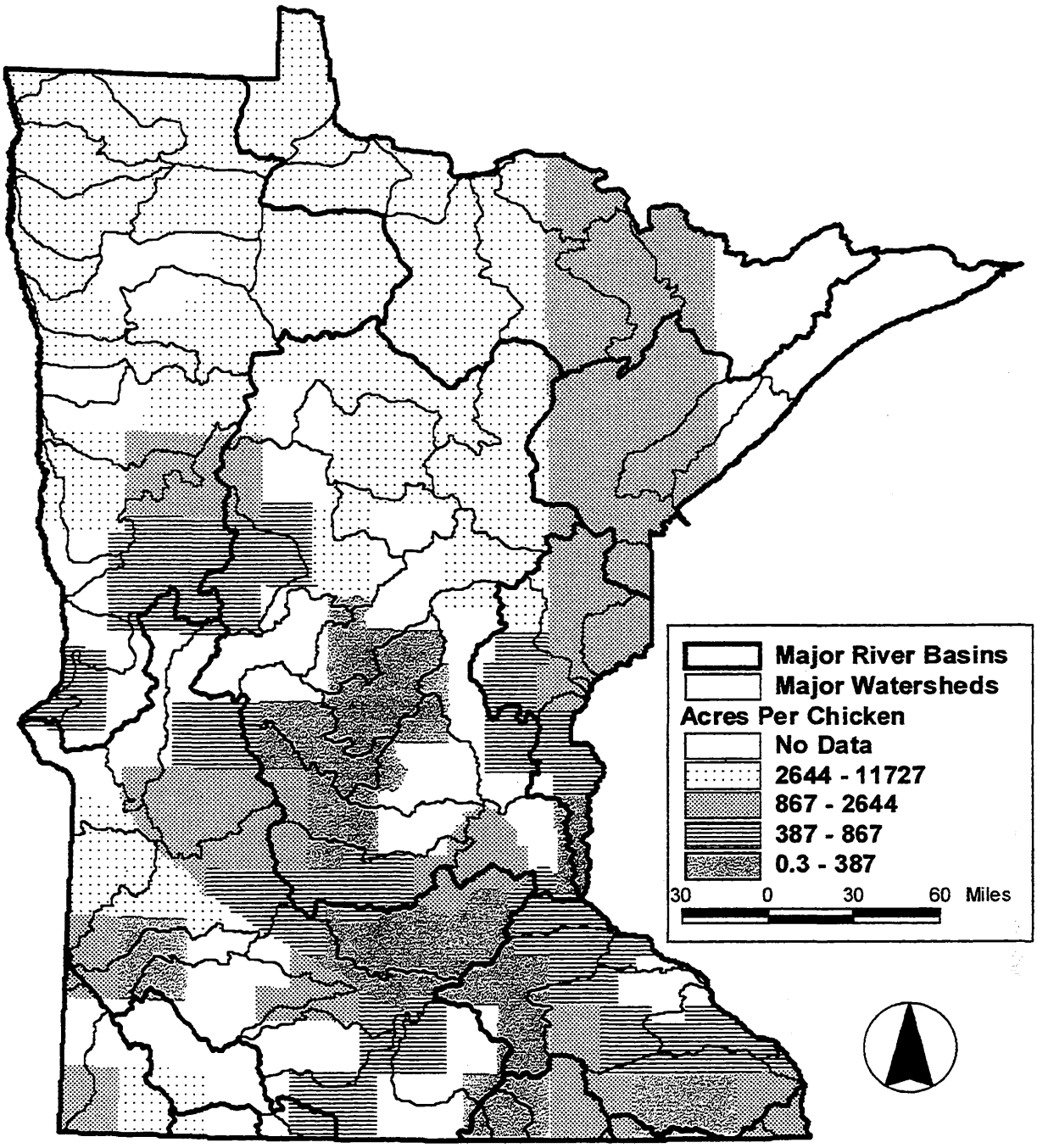

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Fig. 18: County Acres Per Number of Turkeys

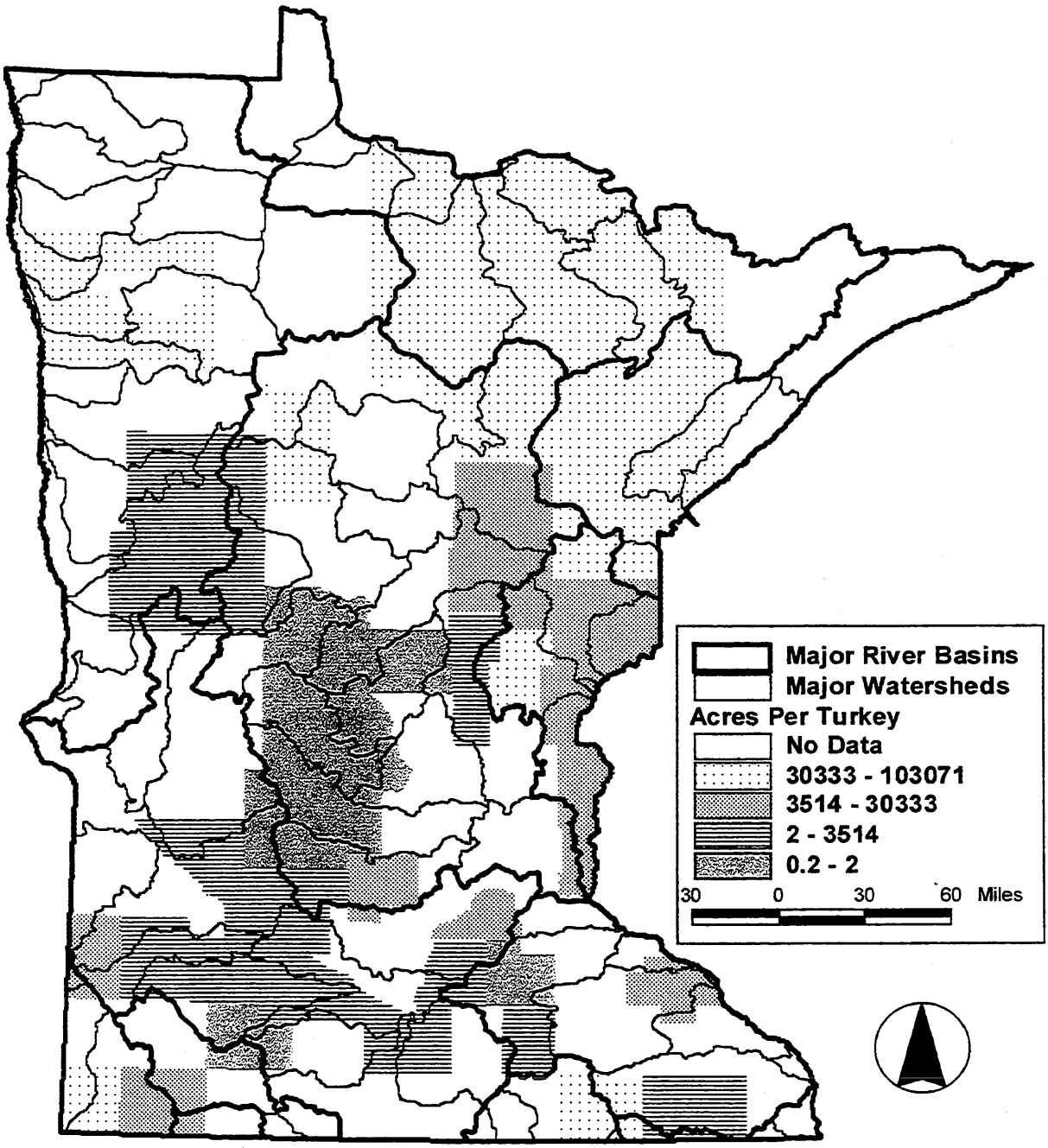

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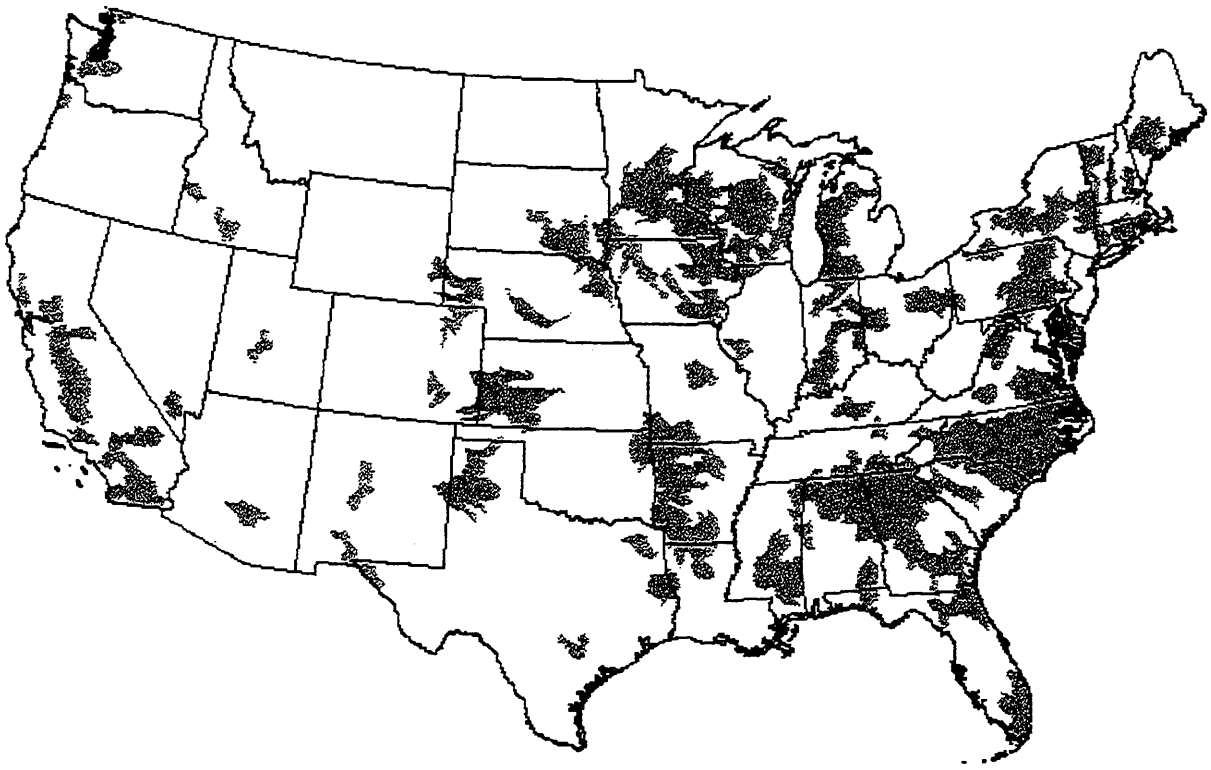
Fig. 19: Watersheds with a High Potential for Soil and Water Degradation from Manure Phosphorus



Since actual water quality degradation patterns are available for Minnesota, we undertook a qualitative comparison between these patterns and the densities of animal populations in Minnesota. In general, it can be concluded that the worst surface water quality problems occur in the southern part of Minnesota, where agricultural land use is more intense than in northern Minnesota. Identification of more specific patterns is, however, difficult.

Rough comparisons between the spatial patterns in cattle and hog population densities (Figs. 15-16) with surface water pollution by BOD (Fig. 7) and fecal coliform (Fig. 8) show few similarities. Spatial patterns in total phosphorus concentrations in surface water (Fig. 10) are somewhat similar to spatial patterns in hog population densities (Fig. 16). Spatial patterns in lakes with poor water quality (Fig. 11) do not seem to resemble spatial patterns in cattle or hog population densities (Figs. 15-16). Poor water quality lakes also occur quite frequently in the heavily populated Twin Cities Metropolitan area.

Rough comparison of the spatial pattern in density of cattle populations (Fig. 15) with spatial patterns in ground water pollution by nitrate-nitrogen (Fig. 14) shows some resemblance. Contaminated ground water in central, southeastern, and southwestern Minnesota coincides with regions having dense cattle populations. Ground water contamination also occurs in areas where cattle are nearly absent, the primary example being heavily populated Washington county. These comparisons should not be considered definitive. There are many other factors which must be evaluated, including human population densities, other agricultural land uses, and application patterns of phosphorus and nitrogen fertilizer. These factors will be considered in section 10 of this report.

Hunt et al. (1995) studied two paired (adjacent) watersheds of similar size and flow characteristics in North Carolina. The watersheds had either lower or higher densities of swine and poultry. The following results were obtained (Table 32):

Table 32: Effect of Animal Density on Nutrient Production, Land Application, and Surface Water loads in North Carolina.

Nutrient Component Assessment	Watershed Characteristics High Animal Density	 Low Animal Density
	ton/yr	
Manure N Production	25.0	6.4
Manure P Production	18.4	3.0
	lb/ac/yr	
Excess N applied to Land	75.6	49.1
Excess P applied to Land	50.8	13.3
	lb/day	
Nitrate-N Load in River	43.2	7.9
Ammonia-N Load in River	2.9	0.7
o-phosphate Load in River	1.3	0.4

These results show that at higher animal density proper credit was not being taken for the nutrient content of manure, leading to greater loads of nitrate-N, ammonia-N, and o-phosphate in streams compared to a watershed with lower animal density.

In Japan, Shimura and Tabuchi (1994) found an excellent relationship between stocking density of pigs and nitrate-N concentrations or loads to rivers. Stocking densities less than 2 animals/ac were associated with nitrate-N concentrations less than 10 mg/L. Animals densities greater than 2 animals/ac were associated with nitrate-N concentrations greater than the drinking water limit. These threshold values for animal density are much lower than those adopted in Europe (6 animals/ac).

Jones et al. (1976) used a statistical analysis to show that nutrient loads in 17 Iowa watersheds increased by 1.3 lb phosphorus and 1.5 lb ammonia-N for each feedlot animal unit where drainage to a stream or tile intake was possible. Animals whose waste entered surface water contributed 16% of the phosphorus load and 6% of the ammonia-N load entering surface waters. Feedlot and pasture animal units without surface drainage pathways to waterbodies did not contribute significantly to degradation of water quality.

Koelsch and Lesoing (1998) developed nutrient budgets for livestock farms which accounted for inputs such as feed, animals, fertilizer, legumes, and irrigation, and for managed outputs such as animals, crops, and manure. The difference between inputs and managed outputs, the nutrient imbalance, represents losses to the environment and additions to soil storage. It would be expected that as this difference increases, the potential for degradation of water quality would also increase. Nutrient budgets estimated for 33 beef and swine livestock operations in Nebraska using this approach are summarized below (Table 33):

Table 33: Nutrient Imbalances as a Function of Farm Operation Size in Animal Units (AU).

	Farm Operation Size		
	<250 AU	250-2500 AU	>2500 AU
Farm characteristics			
Animal Units (AU)	154	668	7597
Crop acres/AU	3.7	1.4	0.2
AU/Crop acres	0.3	0.7	5.0
Nitrogen Imbalance			
ton/yr	9	51	514
% of inputs	26%	55%	56%
Phosphorus Imbalance			
ton/yr	0.6	3.1	66
% of inputs	14%	26%	37%

Based on the results presented by Koelsch and Lesoing (1998), it appears that nutrient imbalances are significantly greater for cattle livestock operations when the number of animals exceeds 1000 AU than for operations with less than 1000 AU. Similarly, imbalances are significantly greater for swine operations with greater than 100 AU than for operations with less than 100 AU. For cattle, it appears that a crop acreage density of >1 crop ac/AU causes significant reductions in nutrient imbalance compared to densities <1 crop ac/AU. For swine operations, there was no significant effect of livestock density on nutrient imbalances. The primary approaches recommended in this study to reduce nutrient imbalances included reductions in nutrient content of feed, and off-site export of manure for land application. The latter strategy would offset the observation that as size of the animal operation increased, the amount of land available for application of manure at agronomically reasonable rates declined.

Percent Losses of N and P with various systems

The type of storage and application method strongly affects the amount of nitrogen lost by volatilization from manure (Burkart and James, 1999), and the amount of land needed to dispose of manure at agronomic rates of nitrogen. In Europe, manure storage basins are required to be covered so that volatilization losses of ammonia are prevented. Representative losses by volatilization in the United States are given in Table 34 below:

Table 34: Representative Losses of Nitrogen from Manure During Storage and Application.

Type of Animal	Volatilization Losses as % of Excretion	
	Storage	Application
Beef cow	60	25
Dairy cow	60	32
Hog breeder	75	5
Chicken broiler	40	2
Turkey	47	2

Massey et al. (1998) illustrate the disparities in N retention that can occur from various swine manure storage systems, assuming N losses due to ammonia volatilization of 92% from lagoons, losses of 50% from earthen pit manure storage systems, and losses of 40% from concrete tanks. As a result, the land needed for manure application to meet corn nitrogen needs from 1000 hogs (Table 35) would vary from 74 ac for surface application of lagoon effluent, 113 ac for injection of lagoon effluent, 620 ac for injection of earthen pit slurry, and 744 ac for injection of concrete tank slurry. As the land required for manure application increases, the critical animal density decreases (Table 35), from 13 animals per acre down to 1 animal per acre. Thus, storage, handling, and application methods with large ammonia volatilization losses of N require fewer acres of land for manure application than methods that involve small losses of nitrogen due to ammonia volatilization. These results assume that the volatilized ammonia from manure storage is not redeposited locally, an assumption that may not be valid.

Table 35: Effect of manure storage, handling, and application methods on land and animal density required for spreading of manure.

Manure Storage, Handling and Application Methods	Average N Loss in Storage	Land Area Needed for Manure Application	Animal Density
	--------%--------	-----acres-----	-----animals/acre-----
Lagoon	92		
Surface Applied		74	13
Injected		113	9
Earthen Pit	50		
Injected		620	2
Concrete Tank	40		
Injected		744	1

Feedlots

Peterson (1998) described Blue Earth county efforts to control nonpoint source pollution from feedlots. Feedlot animal units (AU) increased slightly from 97,130 AU in 1965 to 99,820 AU in 1995. Of these, 197 are cattle operations (avg. 116 AU/site), 331 are for swine (avg. 348 AU/site). The largest county feedlot has 2000 AU. Currently, there are 886 feedlots, of which 101 have less than 10 AU, 301 are inactive, 471 are active, and 13 are pasture operations. The primary pollution hazards are unlined earthen basins (mostly for swine operations) and runoff to surface water (mostly for cattle operations). A total of 49 feedlots (10% of the active feedlots) were identified as pollution hazards, of which 18 had unlined earthen basins, and 30 had runoff hazards. Sixteen of the pollution hazards had less than 50 AU, 32 had between 50-300 AU, and one had greater than 300 AU. Thus, over 90% of the pollution hazards were from small animal operations (<300 AU), and only one was from a moderate size animal operation. No information was provided in this paper regarding the age of feedlots, or on the relationships between feedlot age, size, and pollution hazard.

Sandberg (1998) stated that Minnesota has 45,000 animal feedlots. From 1996-1998 there were 49 compliance problems completed for feedlots. Violations were noted for 16 cattle, 20 hog, 5 dairy, and 2 chicken operations. Problems identified included unpermitted basins, tile inlet discharges to ditches, multiple runoff concerns, overflowing pits or basins, open lot runoff, manure storage in flood plain, unpermitted construction, land application runoff, pumping basin to river, ditch, or wetland, runoff to rivers, overapplication, and stockpile runoff. Violations occurred for operations of all sizes and ages.

Quantitative conclusions about the impact of animal density and feedlot size on surface water quality are difficult to make based on the available data. Some general observations about the relationships between animal density and feedlot size include:

- As size of animal operations increases, the nutrient imbalances also increase. This is mainly due to a lack of proper land area for spreading manure. The critical density depends upon the type of animal, and the methods used in storing, handling, and applying manure to cropland.

- There is a tendency in Blue Earth County for small sized feedlots to be a more frequent pollution hazard than medium or large feedlots. This may occur because medium and larger feedlots tend to be fewer in number, are newer, are better designed, and use improved methods for manure storage, handling, and application than smaller feedlots (Schmitt et al., 1996).

- As the density of animals in a watershed increases, there is an increasing impact on surface water quality. This is primarily due to increased nutrient production in manure, and inadequate crediting of manure in nutrient applications to cropland. The critical threshold density depends upon the type of animal, the region and its characteristics, and waste storage, handling, and application methods.

- Animals located where their waste has a direct pathway for runoff losses to surface waters have a much greater potential to degrade water quality than animals located away from these direct pathways or on pasture land.

- Minnesota animal densities do not appear to be above the critical threshold levels set for animal operations in Europe. Caution must be used in making these comparisons, because county-wide averages may be considerably different than calculations for individual animal operations.

- In some instances, spatial patterns in degraded water quality of ground water appeared to resemble spatial patterns in cattle population densities. This does not prove that animal operations caused the water quality degradation. Areas with large human population densities also coincided with areas having degraded ground water and lake water quality. Other factors not considered include agricultural land uses other than animal operations and fertilizer application rate patterns. Further study is warranted of these relationships.

7. What are the current and potentially available best management practices and mitigation technologies to prevent against ground and surface water pollution from manure storage, handling, and application and to what extent are they effective?

Manure Storage

Manure storage systems are highly varied, but they generally contain manure from the time it is generated until it is utilized (Schmidt and Jacobson, 1994). Storage systems in Minnesota include: under-barn, deep concrete pits; above- or below-ground concrete tanks; above-ground steel tanks; earthen storage basins; solid manure stockpiles; and in-barn manure packs, i.e., poultry houses, hoop houses for hogs, and other confined livestock pens. Certain aspects of each system must be managed to reduce the risk of negative environmental impact. Overflows or leaks from large liquid manure storage facilities pose the greatest environmental hazard associated with manure storage and can be considered a "point source" of pollution when a system breaches. Manure storage systems must safely contain manure nutrients until they can be utilized. The following management guidelines serve to reduce the risk of negative impacts on water quality.

Provide adequate storage capacity. Storage capacity of any system is extremely important because smaller capacities demand more frequent emptying and hauling. This may not always be possible due to inclement weather, frozen soils, cropland availability, or time constraints, e.g., planting or harvesting. With larger storage capacities producers are able to apply manure according to crop and soil needs, rather than having storage capacity dictate when to haul manure. A minimum storage capacity of 9 months is recommended for large liquid manure systems. This larger capacity will improve the likelihood that manure will be applied and incorporated under conditions that minimize the potential for environmental contamination of ground and surface waters.

Keep rain out of storage area. Rain water runoff from open lots and building roofs must be diverted from any storage area. Any "clean" runoff that is not diverted adds to the risk of storage overflow and increases the volume of manure to be transported to the field.

Insure the quality of all storage systems. Earthen storage structures should be properly constructed. Current state regulations require that a registered professional engineer or the Natural Resources Conservation Service design all earthen storage structures. Concrete agitation pads are required on new structures and recommended for older structures. Because linings can be damaged through agitation, it is a good idea to inspect earthen storage structures every five years to insure lining (clay or synthetic) remains intact. Without a proper lining there is a high risk of nitrates leaking into the ground water, especially from along the sidewalls of the structure.

Concrete and steel storage structures must be inspected for cracks or leaks. Steel storage structures must be inspected for leaks. Steel storage structures, i.e., old gasoline storage tanks,

are not allowed to be placed underground.

Stockpile manure on a concrete or clay pad. Runoff should be contained by low sidewalls or gutters. This runoff should be collected, stored, and land applied or treated. In some situations, collecting or treating runoff may be more difficult and expensive than covering the stockpile.

Locate storage systems to avoid potential problems. Keep in mind distances to public or residential areas and water resources when considering where to locate a storage unit. Do not locate storage structures within a natural conveyance system that channels runoff water toward a surface water body. Doing so increases the potential for transport to surface waters of manure spilled during emptying, pumping, or hauling.

Minnesota scientists have summarized the environmental risk of manure storage systems for pork producers in Table 36 (Schmidt and Jacobson, 1994). Relative environmental risk is both site specific and dependent on management practices and proper system design.

To achieve the goal of preventing water quality impacts by manure storage system, guidelines and revisions to the present feedlot rules have been prepared recently by MPCA as Chapter 7020, Draft Feedlot Rules. These rules are currently (1999) in review by the Feedlot and Manure Management Advisory Committee to the MPCA and MDA. These revisions address most manure storage systems and after further review and acceptance should be considered "state-of-the-art" based on recent research and technological improvements.

Manure Collection

A manure collection system handles manure between the place of deposition by the animal and the final storage area. Because many of the newer storage systems are closed, i.e., animals located on slats directly above storage pit, underground pumping system between temporary collection area and final storage basin or tank, etc., the potential effects of collection systems on water quality is of limited concern.

Animals located on open lots is the manure collection system of primary concern. First, care should be taken to locate open feedlots in areas where runoff is not discharged directly to surface waters. If runoff is likely to move directly to surface water, diversions should be constructed to channel the runoff through a grassy vegetative buffer zone before the runoff enters the surface water. This vegetative zone must be sufficiently wide to capture most of the contaminants, but some leakage of soluble constituents, i.e., dissolved P, pathogens, etc., is still likely. Second, berms can be constructed along surface water bodies to prevent direct discharge of runoff to surface water bodies. This method is likely more expensive than vegetative buffer strips, but is also more likely to be successful in reducing runoff losses to surface water. Third, excess rain water coming from roofs or positions above the feedlot should be diverted around the edge of the feedlot. Excess runoff water running through a feedlot will carry manure and, therefore, high concentrations of nutrients with it. Collecting or treating this runoff may often be more difficult and expensive that diverting "outside" sources of water from the feedlot.

Table 36. Relative environmental risk of manure storage systems to water quality.

	Risk[1]
SOLID STORAGE	
Stacking slab	
• concrete pad, roof, runoff control	Low
• earthen pad, no roof, runoff control	Moderate
• earthen pad, no roof, no runoff control	High
LIQUID STORAGE	
Above ground tank (concrete or steel)	
• covered, no leaks	Low
• not covered, no leaks	Low
• not covered, leaks	High
Below ground tank (concrete)	
• covered, no leaks	Low
• not covered, no leaks	Low
• not covered, leaks	High
Deep pit (concrete bottom)	Low
Earthen	
• clay or synthetic liner, clay soils	Low
• clay or synthetic liner, sandy soils	Moderate
• no liner, clay soils	Moderate
• no liner, sandy soils	High
• located in karst area (with or without liner)	High

- Risk is based on storage manure's potential contact with soil or surface waters. All storage capacities are assumed to be at least six months. The storage location is assumed to be at least 300 feet from well or surface water and six feet above the water table.

Similar to Table 36, Minnesota scientists have attempted to rate the environmental risks associated with different types of collection systems for pork producers (Table 37).

Table 37. Relative environmental risk of manure collection systems to water quality (adapted from Schmidt and Jacobson, 1994).

Collection system	Risk[1]
SOLID SYSTEMS	
Pasture	
• low stocking density - no water access	Low
• medium stocking density - slope to water	Moderate
• high stocking density - water access	High
Open lot	
• concrete with runoff control	Low
• clay with runoff control	Moderate
• clay without runoff control	High
LIQUID SYSTEMS	
Deep pit	Low

- For water quality, environmental risk is based on the risk of manure entering surface water or groundwater.

Manure Handling

Manure handling systems for the purpose of this report are defined as those delivery systems/methods that transport manure from the storage facility to the field for land application. Common handling systems include liquid manure tanks, often called "honey" wagons; box spreaders for solid manure sources, i.e., poultry litter and daily scrape and haul dairy enterprises; and irrigation pumps and piping for drag-hose injection or traveling gun irrigation of manure.

Each system has specific management attributes that need to be considered when evaluating their impact on water quality.

Liquid manure tankers are the most common transport system, especially with the larger dairy and hog operations. These tankers can either broadcast liquid manure on the soil surface without immediate incorporation, incorporate the broadcast manure with a tillage tool mounted on the tanker, or directly inject manure into the soil. Environmentally speaking, the latter two methods are desirable because they incorporate the manure into the soil, thereby minimizing runoff and odors associated with non-incorporated manure. An additional benefit is greater availability of manure-N from incorporated manure. Tanker sizes commonly range from 3000 gal. to 6000 gal. with some up to 12000 gal. This range in sizes has both advantages and disadvantages. For growers with smaller fields, the range of smaller-size tankers allows great flexibility in terms of tractor size to operate the tanker. Practical and optimal application rates can also be achieved, sometimes with less soil compaction, then when using the larger rigs. For larger operations, larger fields, and some custom applicators, the large tankers are more efficient because they reduce the number of trips required to deliver and apply the manure to the field. Horsepower requirements are high. Soil compaction, especially in the spring, can be a detriment; hence, the desire to fall-apply manure when using liquid manure tankers. In summary, advantages for liquid manure tankers include great flexibility and practicality while injecting or immediately incorporating the manure to minimize runoff and odor concerns. Disadvantages include soil compaction, which may dictate time of application (fall vs spring) and poor control of application rate. Technology on many newer tankers can control application rate quite well, but older tanker systems give poor rate control, which usually means significant over-application.

Box spreaders also allow great flexibility especially for the smaller livestock operation. Two significant environmental disadvantages exist for box spreaders: unknown application rate (not true for poultry litter spreaders) and lack of incorporation unless done with an additional tillage pass. Manure application demonstrations conducted by University extension specialists often have revealed much higher application rates by the farmer-operators than desired because the volume and weight of manure contained in box spreaders is usually not known. This is contrary to liquid manure tankers where the volume of manure is known and the application rate can be determined quite accurately. Knowing the application rate is not a problem for most applying poultry litter because the manure source tends to be more uniform and their trucks are better calibrated. In summary, lack of immediate incorporation and inappropriate application rate are the primary water quality concerns associated with the use of box spreaders.

Irrigation techniques to transport and apply manure to fields can range from virtually no water quality concern to large concerns. When a well-maintained pump and pipe system is connected to a tow-hose (sometimes called a drag-hose) injection system, no water quality concerns exist unless the application rate is too high (a problem with the operator, not the transport system). Once manure enters the pump at the storage facility, it stays enclosed in the pipe and delivery system until injected into the soil; hence, minimal odor and runoff problems. On the other hand, irrigation of manure onto the soil surface with a traveling gun greatly increases the likelihood of runoff losses, especially on sloping ground, because incorporation usually does not occur for a day or more. In the meantime, significant odor is generated due to

both aerial spraying and lack of immediate incorporation.

In summary, technological improvements have occurred in manure handling equipment during the last decade that allow more precise application of manure. However, there are still plentiful opportunities to improve manure application equipment to the point where it is as precise as commercial fertilizer applicators. This will not come without additional cost to the livestock producer, however. Once dependable precision applicators are available and management and attitude toward manure application are improved, water quality concerns due to manure handling equipment should be minimal.

Land Application

Animal manure has been land-applied for centuries to supply nutrients for improving crop growth and yield. Within the last generation, however, concern that animal manure may be degrading water resources has increased. Reasons for this have been due largely to poor manure application practices, disposal of manure at high application rates, and greater concentrations of animals associated with modern livestock production systems.

Numerous management practices affect the availability of nutrients from land-applied manure, and hence, the potential for nutrient contamination of surface and ground waters. These practices include: (1) rate of application, (2) time of application, (3) incorporation method, (4) nitrification inhibitors, (5) tillage, (6) vegetative filter strips, (7) cropping systems, and (8) wetland treatment.

Rate of application.

Application rate is the single, most important manure management practice affecting the potential for contamination of water resources by nitrogen from manure. Simply said, applying nutrients in excess of crop need, whether from fertilizer or manure, increases the potential for nutrient (N and P) movement to ground and surface water. A medical analogy emphasizes the point. Doctors prescribe medicines at a specific dosage rate to combat disease/illness. Using a lesser dosage rate, diminishes the effectiveness of the medicine. Using a larger rate leads to unwanted side effects and perhaps long-term negative consequences. The same is true with animal manure. However, arriving at the proper manure rate is more difficult because: (1) nutrient content among manures varies substantially, (2) application equipment is often not sufficiently precise, and (3) climate and soil properties influence the availability of nutrients from manure.

Nutrient content of manure will vary with the animal species, size of animal, and storage facility. Surveys by extension specialists of nutrient analyses from manure samples submitted to laboratories have shown the N content of hog manure to range from less than 3 to more than 100 pounds of total N per 1000 gallons. Thus, to improve application rate accuracy, it is extremely important to know the nutrient content of the manure being used because the nutrient rate is the factor that determines agronomic benefits and environmental consequences. Farmers should

obtain nutrient analyses from manure in each storage facility for a few years to obtain a record of nutrient content. This will greatly aid them in designing a manure application strategy that matches crop nutrient needs on their farm. If farmers do not have manure analyses records, general nutrient analyses for a number of livestock species can be found in Midwest Plan Service 18 (1985). A recent publication giving the nutrient content of manure collected from 430 Minnesota farms between 1994 and 1997 is an excellent source of manure management information for Minnesota producers (Schmitt, 1999).

Availability of manure-N in the first year and credits for second-yr availability also must be considered if application rates are to be accurate. First year availability of manure-N is affected primarily by livestock species and method of incorporation. Availability of N in hog manure can range from 35 to 80% depending on method of incorporation, whereas N availability in dairy manure ranges from 20 to 55% (Schmitt, 1999). Nitrogen availability in poultry manure ranges from 45 to 70% depending on how quickly the litter is incorporated. Second year availability of N is much greater for dairy manure than for swine manure.

Availability of P and K in manure is more generalized: P = 80% and K = 90% in the first year. Because these nutrients are not generally mobile in the soil and availability is high, long-term application rates in excess of crop needs will lead to buildup of soil test P and K.

University of Minnesota soil scientists have monitored the effect of manure application rate on the downward movement of N to ground and surface water (tile drainage) in research conducted at Morris, Olmsted Co., and Waseca. The following discussion briefly summarizes the findings.

Morris. Extremely high rates of solid beef, liquid beef, and liquid hog manure were applied to a Tara-Doland silt loam in 1970 and 1971 and were compared to a recommended rate of commercial N fertilizer (Evans et al., 1973; 1974; 1975; and 1980). During the 2-yr period, application rates of solid beef manure totaled 200 tons/acre (4850 lb N and 1045 lb P/acre); liquid beef manure and liquid hog manure totaled 568 tons/acre (134,000 gal/acre). Nitrogen and P applied in the liquid beef manure totaled 9160 lb N/acre and 1105 lb P/acre, while 3370 lb N/acre and 395 lb P/acre were applied in the liquid hog manure. All applications were incorporated as best possible. By the fall of 1972, NO_3 had moved to a depth of 8 feet with all manure treatments with substantial amounts to 10' with the liquid beef treatment. Corn grain yields were not affected by the high manure rates compared to the fertilized treatment. In October 1978, seven years after the last manure application, significant quantities of NO_3 were still found throughout the 0-16' profile with the liquid beef treatment. Some residual NO_3 still remained to a depth of 14' with the solid beef and liquid hog treatments. Corn grain yields in 1978 were highest from the solid beef manure with no difference in yield among the liquid beef, liquid hog, and commercial fertilizer treatments. Application of these large rates of manure readily show: (1) rapid movement of NO_3 to below the rooting depth within 2 yr of manure application, (2) movement of excess NO_3 throughout the 16' profile seven years after application, and (3) no detrimental effect of manure on corn grain yields in this moderately well drained soil in Western Minnesota.

Waseca. Solid dairy cattle manure taken directly from the barn was applied frequently to a Webster clay loam and incorporated during 1971-1973 at Waseca (Randall et al., 1975). The objectives were to determine: (a) the capacity of land to serve as a sink for excessive rates of manure, (b) the accumulation and movement of nutrients in the soil profile, and (c) the response of future crops to these high rates. Manure was applied to the same 0.5-acre area in both 1971 and 1972. In 1973 the area was split; manure was applied to a 0.25-acre area and corn planted on the other 0.25-acre area. Corn was grown in 1974 on both areas plus an adjacent area that had been fallowed in 1971-73.

Manure applied in 1971-72 totaled 199 tons/acre whereas the 1971-73 application totaled 343 tons acre on a dry matter basis. On a fresh weight basis (82% water and 18% solids), these rates totaled about 1105 and 1905 wet tons/acre, respectively. Nutrient rates for the 2-yr and 3-yr applications were as follows: total N = 11,810 and 20,170 lb/acre and total P_2O_5 = 7330 and 13,290 lb P_2O_5/acre, respectively. To obtain optimum incorporation, the areas receiving manure were tilled (disking, field cultivating, or periodic plowing with either a moldboard of chisel plow) 15, 24, and 27 times during 1971, 1972, and 1973, respectively.

Soil samples taken to a 10-foot depth in May 1974 showed NO_3-N in the top 5 feet totaled 304 and 496 lb/acre for the 199 and 343 ton/acre rates, respectively. Leaching of NO_3-N was evident to depths of 7 ft and 9 ft for the two rates, respectively. Nitrate-N movement below 9' was not found, indicating significant climate and soil differences between this study area and the previously described Morris study. These data suggest that great amounts of N were lost by denitrification when excessively high rates of dairy manure were applied to this poorly drained soil. Denitrification losses at Morris were not as apparent.

In Minnesota, Bray P_1 tests for soil test phosphorus levels greater than 21 ppm are considered very high, with no crop response expected for additional phosphorus additions to soil. Soil test P (STP) levels at Waseca were increased substantially by the high manure rates. Initial STP in 1970 for the experimental area was 30 ppm Bray P_1. In 1974, the STP was increased to 285 and 415 ppm by the 199 and 343 ton/acre rates, respectively. Movement of STP below the top 12 inches did not occur with the 199-ton rate. However, STP in the 12 to 24" layer was 3X higher for the 343-ton rate compared to the fallowed area. Movement of phosphorus below 24 inches was not observed.

Grain yield of corn was depressed significantly by the manure treatments in 1973. Because of the rolling and curling of leaves during a period of dryness in late June and mid-July, high salt content of the manure-amended soil was thought to be the cause. Grain yield was not affected in 1974.

Olmstead Co. Hog manure from a finishing barn pit was applied and incorporated immediately at two rates (6050 and 9200 gal/acre) in 1987 and 1988 for continuous corn grown on a Port Byron silt loam. (Lower application rates could not be obtained with the farmer's liquid manure tanker.) Total N applied in the manure was 315 and 490 lb N/A for the two rates. No manure was applied in 1989. Fertilizer N rates of 0, 75, 150, and 225 lb N/acre were applied annually during the 3-yr period. Corn grain yields and NO_3-N concentrations in the soil water at

the 5-foot depth were obtained to determine the agronomic and environmental effects of manure and fertilizer N rates on this highly productive, well-drained soil.

Data shown in Table 38 indicate a substantial corn yield response to both sources of N and a direct relationship between N rate and NO_3-N concentration in the soil water at 5 feet (Randall et al., 1990). Grain yields were optimized with the 150-lb fertilizer N rate and by the lower manure-N rate even though manure was not applied for the 1989 crop. Nitrate-N concentration in the soil water at 5' in September 1989 was 15 mg/L for the 150-lb N rate, but was increased 2.5X and 5X by the 6050 and 9200 gal/acre manure application rates, respectively. Similar to the conclusions from the previously described study at Morris, application of manure at rates exceeding crop demand results in substantial accumulation of NO_3-N in the soil profile and downward movement toward the groundwater aquifer.

Table 38. Effect of fertilizer and manure-N treatments on corn yield and NO_3-N concentrations in the soil water at 5' in Olmsted Co. (adapted from Randall et al., 1990).

Treatment		Grain Yield		NO_3-N conc. in soil water
Source	Total N rate	1989	1987-89 Avg.	at 5'
	lb N/acre	----- bu/acre -----		mg/L
-	0	69	86	1
Fertilizer	75	155	159	7
"	150	181	178	15
"	225	175	171	28
Hog manure	315	187	185	38
"	490	181	184	79

The two manure treatments were continued with varying rates of dairy manure being applied through 1996. At the end of this 10-yr period (1987-1996) the total P rates applied for the two manure treatments were 690 and 950 lb P_2O_5/acre. Soil test P in the 0 to 8-inch layer in 1996 was 63 and 85 ppm for the two manure rates, respectively, compared to 22 ppm on the non-manured control. These data again provide local evidence of rapid increases in STP when manure rates exceed crop needs (Randall and Iragavarapu, 1996).

Waseca. Large areas of cropland in the Midwest are subsurface, tile drained because of poor internal drainage. Substantial amounts of nutrients can be contained in tile drainage water and, depending on the amount of water flow, large losses may occur. Monitoring tile discharge

can, therefore, be useful in assessing the impact of agricultural management practices on surface and groundwater quality.

Nutrient losses in subsurface, tile drainage water have been shown to be affected by nutrient application rates. Nitrate-N concentrations and losses from continuous corn in Minnesota increased with increasing rate of fertilizer N application resulting in very high losses when the N application rate exceeded recommendations (Gast et al., 1978).

Phosphorus losses in subsurface, tile drainage from soils receiving P fertilizes have been shown to range widely depending on various soil properties. Greatest losses have usually been associated with sandy or organic soils with a high water table. Preferential flow has been cited as greatly affecting downward movement of P and subsequent losses, especially in high-clay soils. Ongoing research in Quebec reported by Sims et al. (1998) showed total P concentrations ranging from 0.01 to 1.17 mg L^{-1} in tile drainage with highest P concentrations corresponding to samples taken immediately after extended dry periods when soil cracking could have enhanced preferential flow.

Research documenting P losses in subsurface, tile drainage from soils receiving manure is limited. Dairy manure was applied annually at rates of 0, 16, and 90 tons/acre (wet) to a calcareous, glacial till, silt loam in New York (Hergert et al., 1981). Ortho-P concentrations in the tile drainage water averaged 0.011, 0.014, and 0.218 mg L^{-1} for the three manure rates, respectively, for the 3-yr period. The initial Olson P soil test was 11 ppm and after 3 yr was unchanged with the 16-ton manure rate but was increased to 35 ppm by the 90-ton rate.

A 4-yr study was conducted at Waseca with the objective of determining the effect of liquid dairy manure and urea applied at equivalent rates of total "available" N on (i) loss of N, P, and pathogens to subsurface tile drainage, (ii) corn production, and (iii) change in STP and STK. Equivalent rates of total "available" N were applied and incorporated into a poorly drained Webster clay loam from 1994-1997. Corn was grown each year and tile drainage was collected daily to assess the treatments.

The primary conclusions drawn from this study are:

1) Annual flow-weighted NO_3-N concentrations in the drainage water were not different between liquid dairy manure and urea when applied at total "available" N rates ranging from 138 to 186 lb N/acre.
2) Nitrate-N losses (flux) in subsurface tile drainage did not differ between the urea and manure treatments.
3) Total P exceeded the minimum detection limit in 40 and 52% of the drainage samples from the urea and manured plots, respectively, but the mean TP concentration was not different for the two nutrient sources.
4) Ortho-P exceeded the minimum detection limit in 22 and 35% of the drainage samples from the urea and manured plots, respectively. Losses of ortho-P in the drainage water averaged 0.004 and 0.009 lb/acre/yr for the urea and manured plots, respectively, or about 0.011% of the manure-P applied in the 4-yr.

5) Coliform bacteria were present in all drainage water samples from the manured plots, whereas, *E. coli* was detected in only 24% of the samples.
6) Nitrate-N concentrations were considerably greater in tile drainage water compared to water below the root zone that was percolating to groundwater.
7) Dairy manure applied on a N basis exceeded the P and K needs of the corn and resulted in STP being increased 1 ppm for every 24 lb P_2O_5/acre applied as manure.

The authors (Randall et al., 1999) concluded from this study that a dairy manure management program designed around sound application rates and timing practices does not degrade the environment with respect to N and P losses in subsurface tile drainage water on fine-textured soils. However, continued annual applications of manure at rates to meet the N needs of corn will lead to long-term excessive buildup of STP that may be of concern, especially in environmentally sensitive areas.

Based on the results from these four Minnesota studies, the following broad conclusions can be drawn:

- Animal manure applied at optimal N-based rates does not result in greater N and P losses to ground or surface water compared to commercial fertilizers.
- Manure applied at rates in excess of crop needs likely will result in large losses of NO_3-N to surface and ground water. Movement of NO_3 below the root zone can easily occur within a year or two of excess manure application.
- Climate and soil properties greatly influence the rate and amount of NO_3 movement down through the soil profile. Well and moderately well drained soils are most susceptible to significant NO_3 leaching, especially in wet years.
- Manure applied at optimum N-based rates will raise soil test P in the plow layer. The rate of increase depends on application rate and soil properties.
- Extremely high rates of manure applied for 3 successive years did not increase soil test P below 24" on fine-textured soils.

Time of application

Time of application decisions do not depend solely on biological considerations that maximize manure-N use efficiency, but also on manure storage and handling capabilities, soil conditions, cropping systems, and any other limitations or factors peculiar to an individual farm. Generally, manure application for corn production is limited to either fall or spring, when there is not a crop growing in the field. Fall application of manure is an attractive option for growers from an operational perspective because soil conditions are usually more favorable than in the spring and machinery and labor constraints are usually fewer in the fall.

It has been acknowledged widely that fall application of fertilizer N is agronomically risky. In a review of numerous studies, Bundy (1986) generalized that fall applications of ammonium-N fertilizers are usually 10-15% less effective than spring-applied fertilizers. Concern about fall application of manure parallels fall-applied fertilizer N because of increased

potential for N loss from either leaching or denitrification, which can decrease yield potential and increase negative environmental impacts.

Research conducted in south coastal British Columbia indicated that fall application of liquid dairy manure (535 lb total N/acre) did not increase corn dry matter yield or N uptake compared to a control (Zebarth et al., 1996). Similar rates of spring-applied N, either as manure or commercial fertilizer, resulted in dry matter yield and N uptake that were significantly greater than the control. Fall application of liquid dairy manure (150 lb total N/acre) in North Carolina gave lower corn dry matter yield and N recovery than spring-applied N (Safley et al., 1989). Both of these studies were conducted in areas in which soil temperatures typically remain above 32EF during the winter months, and smaller yields and N removal from the fall manure applications were attributed to N losses during fall and winter.

In contrast, when comparing fall and spring applications of solid, fresh dairy manure in a Wisconsin study, no differences in corn yield were measured when normal rainfall and temperature occurred in the spring; however, fall applications of manure were superior when spring weather was cool and wet (Talarczyk et al., 1996). It was hypothesized that the relative lack of mineralization of manure N with spring applications resulted in this difference.

Studies by Randall et al., (1999) were conducted at seven southern Minnesota sites during 1993-1995 to determine the effects of three manure application times, (mid-September, mid-October, and late April), two manure rates, and a nitrification inhibitor, nitrapyrin (NP), on corn yield and soil NO_3-N concentration (0 to 12 in.) at the V4 growth stage. Application rates ranged from 3000 to 4000 gal/acre for the low rate and from 6000 to 8000 gal/acre for the high rate. For the four sites receiving liquid dairy manure, grain yields for the September, October, and April applications averaged 139, 142, and 146 bu/acre, respectively, across manure rates and NP treatments (Table 39). When liquid swine manure was used, the effects of application time depended on climatic conditions. Under "normal" conditions at two sites, yields averaged 188, 186, and 198 bu/acre for the September, October, and April applications (Table 40). At the site where 8.5 in. of rain fell in a 5-week period in the spring, yields for April application averaged 132 bu/acre compared to 108 bu/acre for October application. Manure was not applied in September at this site. Soil NO_3-N in mid-June was greatest when manure was applied in April and generally least when applied in September. Results from the seven site-yr support about a 5 percent yield increase with April application compared to fall applications.

Table 39. Effect of time of manure application on corn grain yield at six southern Minnesota sites.

Time of application	Dairy manure[1/]	Swine manure[2/]
	- - - - - - - Grain Yield (bu/acre) - - - - - - - -	
September	139	188

October	142	186
April	146	198

1/ Four sites.
2/ Two sites.

In summary, fall application of manure is appealing to producers because this eases constraints associated with spring application, such as high demand for equipment and labor and greater potential for wetter soils and soil compaction in the spring. Results from seven site-yr of field studies indicated that corn grain yield from fall manure application averaged about 5% less than when manure was applied in the spring. Thus, late-fall application of manure, when soil temperatures have cooled, provides an agronomically acceptable alternative to spring application for livestock producers.

Incorporation

Incorporation of land-applied manure is relatively easy to accomplish and greatly minimizes environmental concern. Surface application of manure allows odors to escape and ammonium-N to be lost via volatilization. Some studies have shown >50% of the manure-N to be "lost" (most likely due to volatilization) when manure is not incorporated (Bouldin et al., 1984). Non-incorporated manure also has a much higher probability of being transported to surface water than does incorporated manure. The above factors all contribute to poorer utilization of manure and greater environmental risk when manure is not incorporated.

Loss of P in runoff is influenced by the rate, method, and the time of P application; source of P used; amount and duration of rainfall, and vegetative cover (Randall et al., 1997). Increased loss of P in runoff is frequently reported with increasing application rates of fertilizer P, dairy manure, swine manure, and poultry litter. The dissolved P (DP) concentration in runoff from areas receiving broadcast fertilizer P has been found to average as much as 100 times greater than from areas where comparable rates were applied 2 inches below the soil surface. Incorporation of dairy manure has been reported to reduce the total P (TP) loss in runoff five-fold compared with areas receiving broadcast applications.

Timing between application of P and the first runoff event is also important, especially in situations involving manure. Loses of P from surface-applied poultry and swine manure have been reduced by up to 90% due to P sorption by the soil when rainfall did not occur for three days after application. The major portion of annual P loss in runoff is generally caused by one or two intense storms. If broadcast P applications are made during periods of the year when intense storms or runoff is most likely, then the percentage of applied P lost will generally be greater than if applications are made when runoff probabilities are less.

While runoff and volatilization losses of manure N can be essentially eliminated with application methods that inject manure, losses of manure N can still occur. Scientists have reported up to 50% of the N lost from vertical knife injection thought to be caused by conditions

conducive to denitrification (anaerobic, high amounts of organic carbon for energy, and a nitrate supply from mineralization) (Rice et al., 1988; Comfort et al., 1988, Schmitt et al., 1992b; Sawyer and Hoeft, 1990).

Sawyer et al. (1990) first evaluated horizontal sweep manure application and concluded that this placement alleviated the high concentration of organic carbon and nitrate in an anaerobic zone associated with denitrification. The greater distribution of manure within the soil created by horizontal sweep injection may also favor mineralization and availability of manure N. The combination of greater distribution and reduced N loss conditions resulted in more rapid nitrate-N appearance but no corn yield advantages in these Illinois studies.

A study was conducted at seven locations in Minnesota during 1992 and 1993 to evaluate various liquid manure application methods (Schmitt et al., 1995). Broadcast manure, which was not incorporated with tillage for 7 days, was compared with two methods of manure injection -- vertical knife and horizontal sweep. Dairy manure was used at three locations and swine manure at four locations. Application rates ranged from 3000 to 4000 gal/acre. Corn grain yields averaged across the five locations that responded to manure are shown in Table 40. Yields were increased over the control by 20% for broadcast application, 29% for vertical knife injection, and 38% for horizontal sweep injection. These results clearly show that corn yields were enhanced significantly with horizontal sweep injection of manure compared to the other application methods. Because larger grain yields are associated with greater nutrient uptake, nutrient efficiency is enhanced and environmental risk decreased with preplant horizontal sweep injections of manure compared to broadcasting and vertical knife injection methods.

Table 40. Corn grain yield as affected by liquid manure application method.

Application method	Grain yield bu/acre
Control (no manure)	89
Broadcast	107
Vertical knife	115
Horizontal sweep	123

Studies were also conducted at Waseca in 1996-1998 to compare sidedress application methods of liquid hog manure with a preplant application (G. W. Randall, pers. communication). Hog manure from an under-barn pit was applied at 3000 gal/acre when the corn was about 12 inches tall. Methods included sweep injection, vertical knife injection, and surface banding followed by cultivation to incorporate the manure within 24 hrs. Corn grain yields reported in

Table 41 show no difference between the preplant sweep injection treatment and the sidedress injected treatments. However, yields were decreased about 9 bu/acre when the sidedress manure was band-applied and cultivated in. These 3-yr data clearly show that nutrient availability is equal between preplant (April) and sidedress (June) injected applications of hog manure. Banding the manure on the surface and cultivating it in decreased yield and profit and, depending on the timing of a storm event, could lead to runoff losses of manure to surface waters in addition to the odor concern.

Table 41. Corn grain yield (3-yr avg) as affected by time and method of hog manure application at Waseca.

Application Time	Method	Grain Yield bu/acre
Control	-	107
Preplant	sweep-inject	175
Sidedress	sweep-inject	172
Sidedress	vertical knife	178
Sidedress	surface band[1/]	166

1/ Cultivated in within 24 hrs.

Nitrification Inhibitors

Risk of soil NO_3-N losses associated with fall application of manure may be reduced with the inclusion of a nitrification inhibitor i.e., N-Serve; however, the efficacy of nitrification inhibitors with manure has been somewhat inconsistent. Addition of N-Serve to fall-applied swine manure was effective in reducing N losses in Indiana (McCormick et al., 1984). In contrast, a study in Wisconsin indicated that addition of N-Serve was not an effective inhibitor for liquid dairy manure (Comfort et al., 1988).

Minnesota research has also produced inconsistent yield responses to N-Serve applied with manure. Studies conducted in 1992 and 1993 showed a yield response to N-Serve at 1 of 7 locations, but no statistically significant response when averaged across all locations. In another set of studies in 1993-1995, N-Serve added to liquid manure increased soil NO_3-N content at 3 of 7 locations but increased grain yield at only one location (Randall et al., 1999; Schmitt et al., 1995).

Tillage

Large losses of phosphorus can occur from manured fields where runoff and erosion are severe. Conservation tillage involving coverage of more than 30% of the soil surface with crop residues has often been shown to reduce erosion rates by more than 50%. Since phosphorus can be lost when sediment erodes from a field, conservation tillage can also be an effective strategy for reducing particulate phosphorus losses. Several studies on the reductions in phosphorus losses arising from the use of various conservation tillage practices are reviewed below.

Mueller et al. (1984) studied Total P (TP), Algal Available P (AAP), and Dissolved Molybdate Reactive P (DMRP) losses from conventional, chisel, and no-till corn systems in Wisconsin with and without surface applied manure. As Table 42 below shows, the interactions between tillage and manure are complex. No-till with manure had very high losses of TP, DMRP, and AAP. Chisel plow with manure had the lowest TP, DMRP, and AAP loads, with little sediment loss. TP loads were highest in conventional tillage with or without manure (manure actually reduced sediment loss). Compared to unmanured plots, manured plots had significantly greater losses of P. Keeping manure fully incorporated was key to reducing P losses at the surface. Runoff was somewhat lowered by manure application for all tillage treatments.

Table 42: Effect of tillage and manure applications on mass losses of total phosphorus (TP), soluble phosphorus (DMRP), and bioavailable phosphorus (AAP).

	TP Load	DMRP Load	AAP Load
	----------lb/ac----------		
Conv w/o manure	2114	45	464
Conv w manure	1409	62	348
Chisel w/o manure	821	45	178
Chisel w manure	89	45	62
No-till w/o manure	633	89	214
No-till w manure	1186	945	874

Ginting et al. (1998b) surface applied solid beef manure to moldboard plowed or ridge tilled Forman-Buse soils in western Minnesota with a 12% slope. The application of manure significantly increased soil test P levels. Annual losses of particulate P and total P were similar or lower from manured plots than unmanured plots, because manured plots had less erosion than unmanured plots. Particulate P losses were lower for ridge tilled than moldboard plowed plots. Soluble P losses were higher in ridge tilled plots than moldboard plowed plots during snowmelt runoff. Overall, ridge till reduced total P losses more than moldboard plowing. Soluble P losses were not significantly different between manured and unmanured plots. Approximately 5-6% of the total P in plant residue could be leached away during snowmelt runoff.

Gupta et al. (1997) studied the effect of no-till and disk-till practices on pollution of surface runoff from silt loam plots in southeastern Minnesota receiving liquid swine manure or no manure. Concentrations of total N, total P, ammonium-N, and nitrate-N in manured plots were significantly greater than concentrations in unmanured plots. Concentrations in runoff from disk-till plots were significantly lower than concentrations from no-till plots, due to improvements in soil saturated hydraulic conductivity in the disk-till plots.

Kanwar et al. (1998) found average nitrate nitrogen concentrations of 14 mg/L for chisel plow manure plots in a corn-soybean rotation located in Iowa, and concentrations of 10 mg/L in a chisel plow plot receiving fertilizer at rates equivalent to the manured plot. Under continuous corn, chisel plowed manured plots had an average nitrate concentration of 22 mg/L, while similar plots receiving fertilizer only had nitrate levels of 12 mg/L.

These tillage and manure studies show that conservation tillage is effective at reducing sediment losses by erosion, and this in turn reduces losses of particulate phosphorus. Regardless of tillage practice, the addition of manure to plots also tends to reduce erosion as well as particulate phosphorus losses. Increased residue from conservation tillage systems, combined with additions of manure, tends to increase the losses of soluble and bioavailable phosphorus compared to treatments without residue or manure. In most cases, the reduced losses of particulate phosphorus outweigh the increased losses of soluble phosphorus, so manure applications in conservation tillage systems (chisel plow, ridge till, and disk till) generally have reduced total phosphorus losses as compared to conventional moldboard plow systems.

Vegetated Filter Strips

When conservation tillage practices are not utilized, the runoff and erosion from manured fields can be routed through grass vegetative filter strips to remove sediment and nutrients. The effectiveness of vegetative filter strips at removing pollutants depends upon site-specific characteristics described below.

Schellinger and Clausen (1992) studied removal of N, P, and bacteria in surface runoff passing through a vegetative filter strip from dairy barnyard manure applied to poorly drained silt loam and silty clay loam soils in Vermont. The strip received excessive hydraulic loading, and could not remove N, P, or bacteria to acceptable levels.

Coyne and Blevins (1995) studied the trapping efficiency of grass filter strips for fecal bacteria on a Maury silt loam (9% slope steepness) receiving poultry litter. Grass filter strips 14.8 ft or 29.5 ft in length trapped as little as 23 to 43% of the fecal coliform and fecal streptococci in runoff. Concentrations of fecal bacteria passing through grass filter strips were always greater than 200 CFU/100 mL. While grass filter strips are very effective at reducing sediment loads, they are not very effective at reducing fecal bacteria levels.

Coyne et al. (1995) found that grass filter strips receiving runoff from manured plots were

not effective at reducing fecal coliform counts to levels below 200 CFU/100 mL. Coyne et al. (1998) studied retention of fecal bacteria from runoff through grass filter strips of length 14.8 or 29.5 ft. While the grass strips were very effective at removing sediment (>96% removal), fecal bacteria levels below the grass strips (from 500,000 to 100,000,000 CFU/ 100 mL) were much greater than 200 CFU/100 mL limit. Grass filter strips removed from 75-91% of the fecal coliform and from 68-74% of the fecal streptococci in runoff from manured plots.

Chaubey et al. (1994) applied liquid swine manure to plots of Captina silt loam having vegetated filter strips with widths up to 69 ft. Vegetative filter strips wider than 9.8 ft removed a majority of the incoming nutrients from runoff, but the optimum width was 29.5 ft. Vegetative filter strips were ineffective at reducing nitrate-N and fecal coliform levels in runoff.

Hawkins et al. (1998) found that a vegetative filter strip reduced loads in runoff from land applied swine lagoon waste of total Kjeldahl N, ammonia-N, Chemical Oxygen Demand, and total P by over 90% on an 11% slope and by over 50% on a 5% slope. Ammonium-N and total Kjeldahl N trapped in the vegetative filter strip were converted to nitrate-N which rapidly leached into the soil to ground water at very high concentrations (55.4 mg/L).

Srivastava et al. (1996) showed that as length of a vegetated filter strip increased, there was an associated exponential decrease in the concentrations of nitrate-N, total Kjeldahl N, ammonia-N, orthophosphorus-P, total P, and total organic carbon in runoff from a pasture amended with poultry litter. A majority of the incoming nutrients were removed with a 19.7 ft vegetated filter strip. Filter strips of all lengths were ineffective at reducing fecal coliform in runoff. The mean concentration of fecal coliform in runoff for all treatments was 1.3 million CFU/100 mL.

Younos et al. (1999) monitored stream water quality receiving dairy manure waste before and after installation of an 59 ft wide grass filter strip. There was a significant reduction in soluble and particulate phosphorus transport to the stream after installation of the grass filter strip.

These studies on vegetative filter strips show that their ability to remove pollutants from manured soils depends upon the type of pollutant, the slope of the field, the amount of runoff and erosion, the presence or absence of concentrated flow (rills), and the length of the filter strip. For slopes less than 9%, with dispersed sheet flow runoff (no concentrated flow), filter strips of from 15 to 20 ft in length were able to remove a majority of the sediment, total phosphorus, soluble phosphorus, organic and ammonium nitrogen, and chemical oxygen demand in the incoming runoff from manured plots. Filter strips were not able to effectively reduced concentrations of fecal bacteria in runoff from manured plots.

Related to the issue of filter strips is the issue of setback distances from water. Wall and Johnson (1996) have thoroughly reviewed this issue. They suggested that vegetated buffer strips greater than 100 ft wide should be adequate to remove the majority of sediment and particulate phosphorus from runoff and erosion off of manured croplands. In the absence of vegetative filter strips, they recommended a setback distance of 300 ft for surface water protection.

Cropping Systems

Most of the above management factors that affect land application decisions for manure are governed by the cropping system to which manure is applied. For instance, time of application, incorporation, and tillage decisions can be quite different for row crops than for perennials. Additionally, rate of application is affected by the nutrient demand specific to each crop.

Historically, most people agree that corn is the crop of choice to receive manure. Yet, because of numerous studies by University of Minnesota scientists, solid manure management information is available for soybean, alfalfa, and reed canarygrass in addition to corn (Lory et al., 1995; Schmitt et al., 1993; 1994; 1996; 1998). The following points summarize the findings from these many studies.

- Manure can be applied following corn harvest for soybean at rates totaling about 200 lb available N/acre without incurring environmental risk. At this manure-N rate soybean yield was generally increased 2-3 bu/acre and residual soil NO_3-N was not increased.
- Hog manure can be applied prior to planting alfalfa at rates up to 12000 gal/acre. The alfalfa responds to the P and K in the manure and takes up large quantities of N. After the second cutting, soil NO_3-N levels in the top 2' were not different between the manured and non-manured plots. Applying manure prior to alfalfa establishment has many agronomic benefits and few environmental risks compared to application to established alfalfa.
- Liquid dairy manure can be broadcast-applied at very high rates to established stands of reed canarygrass without damaging stand. Manure was applied at 20,000 gal/acre twice each year for two years for a total of 80,000 gal/acre. Yields were increased substantially due to N in the manure, and soil NO_3-N did not increase below 2 feet. The primary environmental risk with this hand application method is the rapid buildup of P in the top 2 inches of soil, which is susceptible to runoff in major storm events.

In summary, Minnesota farmers have numerous crops that can effectively use animal manure without risk to the environment if proper management practices are used.

Wetlands

One option for removing pollutants from animal waste storage basins is to route the waste through wetlands. The following references show that wetlands are effective at removing incoming pollutants.

Hill et al. (1996) found that a wetland treating anaerobic poultry lagoon waste removed 50% of the BOD, 40-56% of the total Kjeldahl N, 37-53% of the ammonium-N,and 34-37% of the orthophosphorus-P.

Sievers (1997) found that wetlands treating anaerobic swine lagoon waste removed 42-50% of the BOD, 37-40% of the ammonia-N, and 19-27% of the total phosphorus. Removal efficiencies were much greater in summer and fall than during winter and spring.

Holmes et al. (1995) studied improvements in water quality from diversion of dairy milking center waste to a vegetated wetland in Wisconsin. Between the inlet and outlet of the wetland, levels of COD were reduced from 488 to 114 mg/L, BOD was reduced from 168 to 15 mg/L, total P was reduced from 16.9 to 2.8 mg/L, and total Kjeldahl N was reduced from 11.8 to 5.2 mg/L.

These studies show that wetlands receiving confined animal feeding operation waste are very effective at reducing the incoming pollutants. They are typically more effective at removing oxygen demanding substances, ammonium, and organic forms of nitrogen than at removing phosphorus.

8. To what extent does Minnesota animal agriculture contribute to the hypoxia problem in the Gulf of Mexico?

Overview of Hypoxia

Hypoxia is a zone of low oxygen levels (< 2 mg/L) covering an area as large as 7,000 square miles in the Gulf of Mexico in 1997. Unlike freshwater systems where phosphorus is usually the limiting nutrient for growth of algae, in the saline waters of the Gulf nitrogen is the most limiting nutrient for growth of diatoms. Agricultural nitrogen sources have been indirectly identified as a major cause of hypoxia (Burkart and James, 1999). The primary pathway for these nitrogen sources to enter surface waters is via subsurface tile drainage systems on poorly drained soils with high organic matter contents receiving excessive rates of nitrogen from fertilizer and/or manure (Randall and Mulla, 1999).

Sources of Nitrogen to the Gulf of Mexico

Goolsby et al. (1999) recently conducted an extensive study of the riverine sources for nitrogen flowing to the Gulf. They estimated that the mean annual flux of total nitrogen to the Gulf of Mexico from the Mississippi River basin is 1.8 million U.S. tons per year. This nitrogen is primarily in the nitrate form (60%), with one-third being in the organic form. Nonpoint sources account for 90% of the nitrogen entering the Gulf. Roughly 50% of the nitrogen flux originates in fertilizer and mineralized organic matter. Nitrogen from atmospheric deposition, ground water discharge, and soil erosion accounts for another 23% of the nitrogen flux. Animal manure nitrogen accounts for 15% of the nitrogen flux. Municipal and industrial point sources generate 11% of the total flux.

Goolsby et al. (1999) estimate that from 16-19% of the nitrogen flux to the Gulf originates in Iowa and Illinois, with another 6-9% from Minnesota, Indiana, Ohio, and Missouri. Upstream of Joslin, Illinois, the Upper Mississippi River basin, which drains much of Minnesota and western Wisconsin, accounts for roughly 10% of the total nitrogen flux to the Gulf (Table 43). Roughly half of the total flux of nitrogen from the Upper Mississippi River basin originates in the Minnesota River basin, with 4% from the St. Croix River, and 13% from the Mississippi River upstream of the Twin Cities. The Chippewa and Wisconsin Rivers in Wisconsin generate roughly 14% of the nitrogen flux in the Upper Mississippi River. Using figures from Kroening and Andrews (1997), municipal wastewater treatment plants in the Twin Cities and upstream of the Twin Cities generate about 7% of the total nitrogen flux in the Upper Mississippi River basin. The flux from the La Crosse River in Wisconsin is unknown. The contribution to nitrogen fluxes in the Upper Mississippi River from southeastern Minnesota is also not known, but based on the differences between total flux and known fluxes from various tributaries, it is probably around 10%.

Table 43: Total Nitrogen and Phosphorus Loads from Various Rivers in the Mississippi River Upstream of Joslin, Illinois, and for Wastewater Treatment Plants (WWTP) in the Twin Cities Metropolitan Area and Upstream of the Twin Cities (Goolsby et al., 1999; and Kroening and Andrews, 1997).

Source	Total Nitrogen Flux	Total Phosphorus Flux
	----------U.S. tons/yr----------	
Discharge to the Gulf of Mexico	1.8 million	152,320
Mississippi River at Joslin, Illinois	165,154	8,800
Minnesota River at Jordan, Minnesota	59,180	1,488
Mississippi River at Anoka, Minnesota	21,059	1,088
St. Croix River at Prescott, Wisconsin	6,132	241
Chippewa River at Durand, Wisconsin	10,318	811
Wisconsin River at Muscoda, Wisconsin	13,376	727
WWTP in Twin Cities and Upstream	12,273	3,212

Using the figures in Table 43, we can infer that the largest source of nitrogen to the Gulf of Mexico from Minnesota is the Minnesota River basin, which generates roughly 5% of the total nitrogen flux to the Gulf of Mexico. The Mississippi River upstream of the Twin Cities generates roughly 1% of the nitrogen flux to the Gulf. Wastewater treatment plants in the Twin Cities and upstream of the Twin Cities generate around 1% of the total nitrogen flux to the Gulf. Streams in southeastern Minnesota draining to the Upper Mississippi River probably generate about 1% of the nitrogen flux to the Gulf of Mexico.

The information in Table 43 shows that Minnesota contributes roughly 4% of the total phosphorus flux to the Gulf of Mexico. Wastewater treatment plants are responsible for at least half of this contribution. In comparison, nonpoint sources from the Minnesota and Upper Mississippi River basins are together a smaller source of total phosphorus than wastewater treatment plants.

Contribution of Minnesota Animal Manure to Hypoxia

Total nitrogen loads generated from nonpoint sources in Minnesota account for roughly 7% of the nitrogen loads to the Gulf of Mexico. Identifying the specific contribution to nitrogen loads in the Gulf of Mexico from animal manure nitrogen in Minnesota is a difficult task. Burkart and James (1999) have made a start at such an estimate for major basins in the Mississippi River drainage area by compiling basin averaged information on nitrogen sources from soil organic matter, inorganic fertilizer, ammonia and ammonium redeposition, manure, fixation, and atmospheric deposition. They also evaluated nitrogen losses due to harvest, plant senescence, volatilization of manure and fertilizer nitrogen, and soil denitrification. They did not estimate nitrogen immobilization.

Burkart and James (1999) estimated that watersheds in much of southern and central Minnesota had nitrogen excesses (sources minus losses) from all sources of between 52 and 115 lb N/ac. These are the amounts which are potentially available for loss to surface waters. These nitrogen excesses were among the highest values observed in the entire Mississippi River system. For the entire Mississippi River system, manure represented about 13% of the sources of nitrogen. This is the amount available for runoff, leaching, and soil storage. It is quite close to the estimate by Goolsby et al. (1999) that 15% of the nitrogen entering the Gulf of Mexico originates in animal manure. If we assume that all of the excess nitrogen from manure enters surface waters, and the fact that nonpoint sources in Minnesota generate roughly 7% of the nitrogen loads to the Gulf of Mexico, then manure nitrogen from Minnesota generates roughly 1% of the nitrogen loads to the Gulf of Mexico. This is a worst case scenario.

This estimate of the contribution to hypoxia from Minnesota animal manure is somewhat speculative. Minnesota is different from many other states in that it has soils which are very high in organic nitrogen content and extreme climatic conditions can strongly influence nitrogen losses through artificial drainage systems to rivers (Randall and Mulla, 1999). Fluxes of nitrogen through tile drainage systems are more important in Minnesota than many other states (Brezonik et al., 1999), and losses of nitrogen in ditches and small streams through denitrification can be very rapid (Mulla and Addiscott, 1999). For these reasons, a more thorough analysis of the issue of Minnesota's animal agriculture contribution to the hypoxia issue is warranted.

9. THE EFFECT OF LIVESTOCK ON WATER QUANTITY AND QUALITY

Minnesota is blessed with an abundance of water resources with over 10,000 lakes, thousands of rivers and countless numbers of underground water reservoirs. Sustaining both the quantity and quality of these water resources is an objective all Minnesotans share. Competition for water resources comes from plants, animals and human needs and usage. The following section reviews the quantity of water needed by livestock in Minnesota and the effect livestock can have on surface water runoff and infiltration into groundwater.

Water Dynamics in Minnesota

Annual precipitation averages 25.5 inches in Minnesota, but varies by 13 inches from the southeast to the northwest corners of the state. This average annual precipitation supplies approximately 37 trillion (37_10^{12}) gallons of water annually. Water exits Minnesota by surface streams and rivers, evaporation, plant transpiration, and too a lesser extent, groundwater flow (both deep and shallow underground water). Surface flows from rivers leaving Minnesota average 11 trillion gallons per year. Minnesota's lakes and groundwater aquifers store vast amounts of water and, together with streamflow, represent important sources of freshwater for industry, power generation, agriculture, and public consumption (Department of Natural Resources, 1959, Walton, 1975).

Livestock Water Usage

Livestock water use includes water for consumption and associated on-farm use for the production of milk, meat, eggs and wool. Most of the non-consumption water use on livestock farms is for cleaning of equipment and facilities with dairy and swine farms being the largest users in this category.

Livestock included in the water use survey include dairy, beef, sheep, chickens, hogs and horses. The change in the total number of these animals in Minnesota over the last 33 years is shown in Table 44. Dairy, beef and sheep numbers have declined whereas chicken and swine numbers have increased slightly. Horse numbers were not available for 1965, but a significant increase of over 100,000 horses has occurred between 1992 and 1998.

Table 44. Animal Numbers in Minnesota

	Animal Numbers			Animal Units[5]	
Class	1965[1]	1992[2]	1998[3]	1965	1998
Dairy:	---------- 1,000 head ----------			--- million units ---	
Milk cows	1,407	675	570	1.83	.74
Heifers (+500 lb)	n/a	315	295	.53	.22
Beef:					
Cows & heifers (+500 lb)	513	445	485	.38	.36
Steers & bulls	n/a	520	510	.56	.56
Sheep & lambs	687	293	170	.10	.02
Chickens	13,788	14,400	14,730	.08	.08
Hogs	2,990	4,900	5,500	.75	1.38
Horses & ponies	n/a	43	155[4]	--	.12

Minnesota Crop & Livestock Reporting Service. 1965. Minnesota Agricultural Statistics. MN Crop & Livestock Reporting Service, St. Paul, MN.
Minnesota Agricultural Statistics Services. 1992. Minnesota Agricultural Statistics. MN Ag Statistic Service, St. Paul, MN.
Minnesota Agricultural Statistics Service. 1998. Minnesota Agricultural Statistics. MN Ag Statistic Service, St. Paul, MN.
Minnesota Agricultural Statistics Service. 1999. Minnesota Ag News. MN Ag Statistic Service, St. Paul, MN.
Animal units (1,000 lb equivalency) = Dairy cows, 1.3; dairy heifers, .75; beef cows/heifers, .75; steers/bulls, 1.1; sheep/lambs, .15; chickens, .006; hogs, .25; and horses/ponies, .8.

Converting the animal numbers from 1965 and 1998 to 1,000 lb animal units and assuming dairy heifers numbers were 703,500 in 1965, beef steers/bulls were 510,000 in 1965 and excluding horses for both years, Minnesota has decreased from 4.2 million units in 1965 to 3.4 million units in 1998. Including horses in the 1998 figures and not in the 1965, shows Minnesota still has 17% less animal units in 1998 than 1965.

Water consumption amounts per day for various livestock are in Table 45. Average consumption gallons per day were multiplied by the animal class numbers in Table 44 to figure the total livestock water consumption per day. The total water consumed by livestock each day in Minnesota is estimated to be about 50 million gallons. This agrees closely with the 62 million gallons reported by the U.S. Geological Survey in 1995 which included water consumption by livestock defined here as well as fish, pets, rabbits and all fur-bearing animals in captivity (Solley et al., 1998).

Table 45. Water Consumption[1]

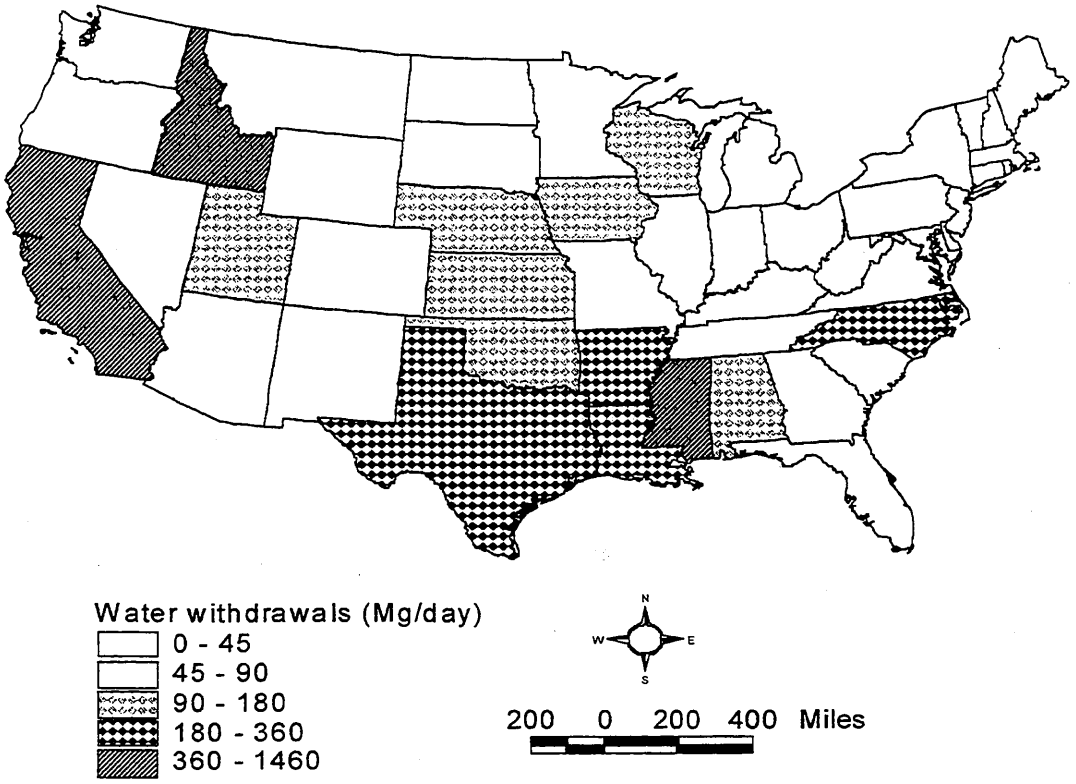
Class	Gallons/animal/day	Total gallons/day
Dairy:		
Cows	22 - 26.1	13,708,500
Heifers (+500 lb)	6.3 - 10.6	2,492,750
Beef[2]		
Cows & heifers (+500 lb)	9 - 15	5,820,000
Steers & bulls	9 - 14	5,865,000
Sheep	1 - 1.5	212,500
Chickens	.06	883,800
Turkeys	.12	4,718,500
Hogs	~3.5	19,250,000
Horses	10 - 12	1,705,000
Total		54,656,050

Gillespie, J.R. 1998. Animal Science. Delmar Publishers, New York, NY.
Guyer, P. 1997. Water Requirements for Beef Cattle. Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

Non-consumptive water use on a livestock farm is highly variable depending on animals raised and type of or no housing facility. Dairy and swine are most likely to be the largest users of non-consumption fresh water because of their housing, management practices and, for dairy, cleaning the milking equipment. Based on the Midwest Plan Service (1995) estimates of non-consumption water use and personal observations (J.G. Linn) of on-farm estimates, an estimated 50 gallons of fresh water per cow per day is needed for non-consumption purposes. Water usage for cleaning swine facilities ranges from 2 gallons per nursery pig per day to 35 gallons for a sow and litter per day (Midwest Plan Service, 1983). Assuming an average daily use of 15 gallons per hog, 50 gallons per milk cow and zero non-consumption water use on other livestock farms, the total daily water use on livestock farms including consumption increases to 160,937,550 (160.9 million) gallons per day.

The Department of Natural Resources estimated the total water used in Minnesota for power generation, public usage, industrial processing, irrigation and other uses per day was 3.25 billion gallons in 1994 (Minnesota Department of Natural Resources, 1996). The 54.6 million gallons of water consumed by livestock represents only 1.7% of the state water usage each day. Minnesota's freshwater withdrawal per day for livestock consumption is less than neighboring states, Iowa and Wisconsin, and considerably less than many southern and western states (Figure 20). The total water usage estimate on farms for consumption and non-consumptive purposes (165.6 million gallons) accounts for 5.1% of the total water used in Minnesota each day.

Fig. 20: Total Livestock Freshwater Withdrawals by State, 1995.



Effects Of Animal Agriculture On Hydrology

Research on the effects of animal agriculture on hydrology tends to focus on the role that animal production activities play in changes in the rates of water infiltration into the soil and surface runoff. Literature in this area typically addresses one of the following three topics: (1) effects of upland grazing on hydrology; (2) animal feedlot hydrology, and; (3) effects of animal activities in/near riparian (adjacent to stream) areas.

Upland Grazing

Animal grazing affects upland hydrology by impacting both soil and vegetative properties of the landscape. Grazing puts pressure on grasses, affecting their ability to filter and slow the movement of water down the hillslope. Animal traffic and trampling puts additional pressure on the vegetation, in addition to inducing deleterious changes in soil properties, such as increased compaction. Water infiltration rates into the soil on grazed lands have been found to decrease significantly (up to 30%) with increased stocking density, causing increased runoff and sediment loss. Much research in Texas indicates that the effects of season can also be quite significant, where the negative effects of grazing are exacerbated during winter or minimum vegetative growth months. During the active growing season, however, grasses are naturally more resilient to grazing pressures, a fact that bodes well for northern climates where winter snow cover often precludes grazing. Moreover, previous reviews on grazing systems have concluded that no consistent significant advantage exists by implementing continuous or rotational grazing systems where heavy stocking rates are used Cheavy stocking rates are universally detrimental to rainfall infiltration into the soil. (Warren et al., 1986a, 1986b, 1986c; Thurow et al., 1986; Van-Keuren et al., 1979).

Animal Feedlot Hydrology

Confined animal feedlot operations require placement of concentrated numbers of animals in unpaved or partially paved areas. Virtually all studies affirm that concentrated animal populations and animal traffic cause increased soil compaction. Much research was conducted in the 1960's and 1970's on characterizing soil condition in animal feedlots with specific emphasis on soil physical properties, water holding capacity, infiltration, and runoff. In feedlots, a dense soil layer typically exists near the soil surface that decreases water intake. In Nebraska, the water permeability of the dense layer was found to be 28-fold lower than the next layer 3.9 in deeper (Meilke and Mazurak, 1976).

Although the soil/manure mixture that constitutes the surface layer has been found to be capable of absorbing a one-half to one-inch rainfall, the dense soil layer impedes infiltration, causing greater runoff volumes and peak flows. Data from Wisconsin were cited in a North Carolina study that demonstrated surface runoff of up to 50 percent of annual rainfall from feedlots that had 76 percent bare soil (24 percent concrete surface), and up to 85 percent of annual rainfall for feedlots with 24 percent bare soil (76 percent concrete surface, Overcash and Phillips, 1978). In South Dakota, researchers determined that one half of annual runoff from feedlots was attributed to events

that may not produce runoff on surrounding (non-feedlot) areas, but that much of this runoff could be controlled with the appropriate use of detention basins and diversions of drainage from outside the feedlot (Madden and Dornbush, 1971). Rapid drainage of feedlots is desirable and is often achieved by use of mounds, drainways, terraces/basins, or inlet risers with underground drains. Researchers in Nebraska have stated that the hydrologic impact of feedlots is on the immediate watershed depending on topography, climatic factors and the characteristics of the feedlot area, and that their hydrology should be considered in feedlot design and management (Swanson, 1973).

Animal Activities In/Near Riparian Areas

Most investigations of livestock grazing effects on streams, rivers and riparian zones have been conducted in arid western states, but evidence exists that suggests that environmental impacts in humid and sub-humid regions are similar to those in the arid west. Researchers in Oregon recently published an extensive survey of livestock influences on stream and riparian ecosystems in the western United States. Their findings are summarized in Table 46. Riparian ecosystems play a valuable role in the landscape by acting as sponges during flood events, raising watertables and maintaining a source of streamwater during drier seasons. Riparian ecosystems are dependent, however, on streambanks and floodplains being in a relatively pristine state. In the west, cattle have been found to cause significant damage to riparian ecosystems. Cattle prefer and tend to congregate in the moist cool environment of the riparian area, spending from five to 30 percent more time there than in upland areas. Consequently, grazing pressure on riparian vegetation is disproportionate when compared to upland grazing. Overgrazing of riparian vegetation and trampling associated with animal congregation set off a sequence of deleterious impacts that actually alter stream geomorphology (shape and flow characteristics). The causes and impacts displayed in Table 46 include both direct and indirect effects of livestock activities on stream and riparian habitats (Belsky et al., 1999).

Table 46: Effects of livestock grazing and trampling on aquatic and riparian species and habitats in the western United States (adapted from Belsky et al., 1999).

Influence on	Response	Causes	Impacts
stream channel depth	increases	downcutting (incision due to higher flood energy in high gradient, erosional stream regimes due to overgrazing	lowering groundwater table; narrowing of riparian zone; high glows contained within channel, thus precluding build-up of flood plain; more downstream sedimentation
stream channel width	increases	breakdown of streambanks by trampling; increased erosion from greater flood velocity; erosion of streambanks due to reduced resistance from riparian vegetation	further loss of riparian vegetation; higher water temperatures; decreases water depth
stream channel stability during floods	decreases	bare streambanks and channel bed easily eroded due to reduced riparian vegetation	widening of channel; loss of pools and meanders
stream water depth	decreases (except during peak flow)	wider stream bed created by above causes	higher water temperatures; reduced habitat for aquatic organisms
Runoff	increases	reduced water infiltration into soils due to compaction and loss of streamside vegetation	increase in sheet and rill erosion; increased flooding; reduced groundwater recharge; lowered water table
peak flow	increases	larger volume of runoff flowing directly into channel	increased stream energy for channel erosion, downcutting of channel bed and gully formation
Flood water velocity	increases	reduced resistance from streambank and instream vegetation and from downed woody debris; increases flood water volume	increased erosive energy and downcutting; removal of submerged vegetation and woody debris for pool formation; reduced habitat diversity; fish vulnerable to flash floods
Summer and late-season flows	decrease	less water stored in soil; lowered water table	aquatic organisms stressed by reduced water quantity; less aquatic habitat; higher water temperatures
Watertable	lowered	reduced water infiltration and increased runoff; groundwater drains into incised streambed; deeper channel reduces recharge by stream	loss of aquatic and riparian species; perennial streams become ephemeral; loss of ephemeral streams

10. How does animal manure compare to other types of wastes produced in Minnesota as a source of water pollution?

The primary sources of nutrients that cause water pollution in Minnesota include animal waste, human waste, migratory wildfowl wastes, fertilizers, and recycled nutrients from the soil. Estimating the relative magnitude of the impacts from each source is a difficult task involving several assumptions. In the following sections, we will summarize what is known about these sources in Minnesota.

Waste Characteristics

Clanton (1993) summarized the daily production of pollutants in manure excreted from various animals normalized to a weight of 1000 lb. This gives the pollutant production per animal unit for each type of animal (Table 47). This comparison shows that for equal masses of live weight, ducks produce more nitrogen and phosphorus than any other animal. Of course, it takes 333 ducks to produce a live weight of 1000 lb. In these terms, the waste produced by two pigs is just about equivalent to the nutrient content of the waste from 333 ducks. It would take 8 humans to produce an amount of nitrogen equivalent to that produced by 1 hog.

Table 47: Daily Production of Potential Pollutants in Manure for Various Animals Normalized to a Weight of 1000 lb (One Animal Unit).

Animal	Typical Weight	Total Nitrogen	Total Phosphorus
	----------lb----------		
Dairy cow	1400	0.52	0.16
Beef cow	800	0.43	0.12
Swine	135	0.81	0.3
Laying chicken	4	1.0	0.39
Turkey	15	0.7	0.23
Duck	3	1.5	0.79
Human	160	0.1	0.009

Ritter (1988) and Long and Painter (1994) summarize the oxygen demanding characteristics of various sources of untreated waste (Table 48). The disparities between animal waste and human waste are even greater for oxygen demanding substances than for nutrients. For equal volumes of waste, the BOD from pig manure is at least 40 times more potent than the BOD from human waste.

Table 48: Biochemical Oxygen and Chemical Oxygen Demand from Various Types of Wastes.

Waste Type	BOD	COD
	----------mg/L----------	
Domestic sewage	100-300	400-600
Dairy cattle manure	6,000-25,600	68,200-168,000
Beef manure	6,700	72,900-258,000
Swine manure	12,800-33,000	25,000-176,400
Chicken droppings	9,800-24,000	100,000-255,000

Animal Waste

The manure nitrogen and phosphorus content of all cattle, hogs, chicken broilers, and turkeys in Minnesota was estimated using the county-wide numbers of animals from the National Agricultural Statistical Service (1997) and the average nutrient content of manures from Minnesota Department of Agriculture. The state-wide total nutrient content of animal manure excreted is 244,566 tons/yr of nitrogen and 65,862 tons/yr of phosphorus.

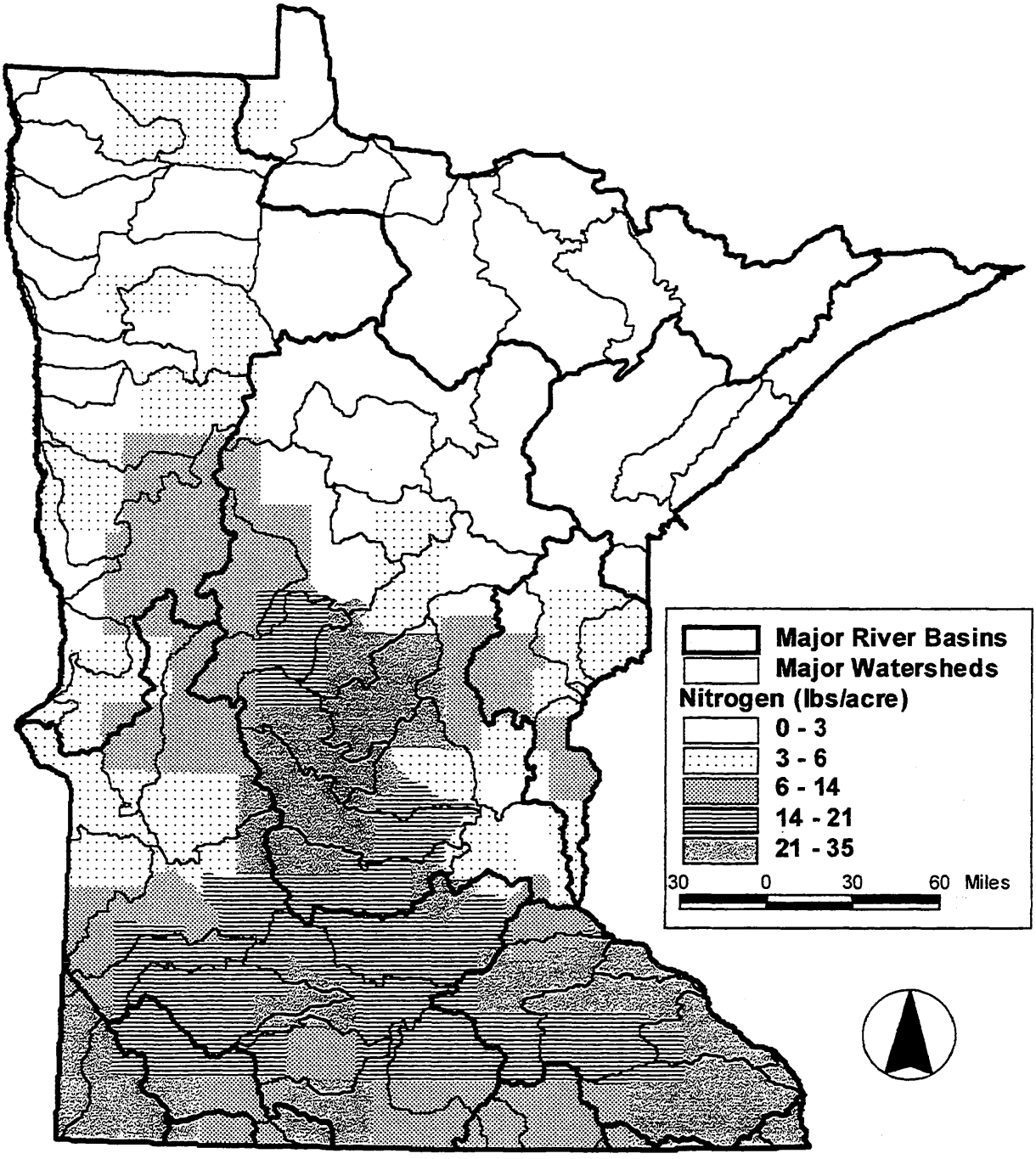
Not surprisingly, the spatial patterns in manure nutrients (Figs. 21-22) show a concentration in central Minnesota, south central Minnesota, southeastern Minnesota, and southwestern Minnesota. Caution should be used in interpreting these figures, especially for nitrogen, since they do not account for volatilization losses that occur with storage, handling, application, denitrification, etc.

Human Waste

Minnesota has 4.7 million residents as of 1997. Three fourths of these were over the age of 15 years old. Assuming that adults excrete 7 lb nitrogen/yr and 3.3 lb phosphorus/yr (Montgomery, 1991), and that those under the age of 15 years excrete on average half that amount, we can estimate the county-wide nitrogen and phosphorus content of human waste. The state-wide total nitrogen content of human waste is 14,503 tons/yr, while the phosphorus content is 6,855 tons/yr.

Unlike animal waste, human waste is typically discharged directly into waterbodies after treatment to remove solids, biochemical oxygen demand, and pathogens. Phosphorus and total nitrogen losses during waste treatment are typically small, especially for total nitrogen. At the metropolitan wastewater treatment plant in St. Paul, roughly half of the incoming phosphorus is removed during the treatment process. Wastewater treatment plants in the Twin Cities Metropolitan area and upstream along the Minnesota River, Mississippi River, and St. Croix River discharge 12,273 tons/yr of nitrogen, and 3,212 tons/yr of phosphorus (Kroening and Andrews, 1997). The largest plant, the metropolitan plant has discharged an average of 967 U.S. tons/yr of phosphorus from 1985-1996 (HydroQual, 1999). This is equivalent to the P load from the Upper Mississippi River, and 65% of the entire load from the Minnesota River.
Fig. 21: Nitrogen Content of Manure Produced per County Acres

Fig. 21: Nitrogen Content of Manure Produced Per County Acres



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University of Minnesota
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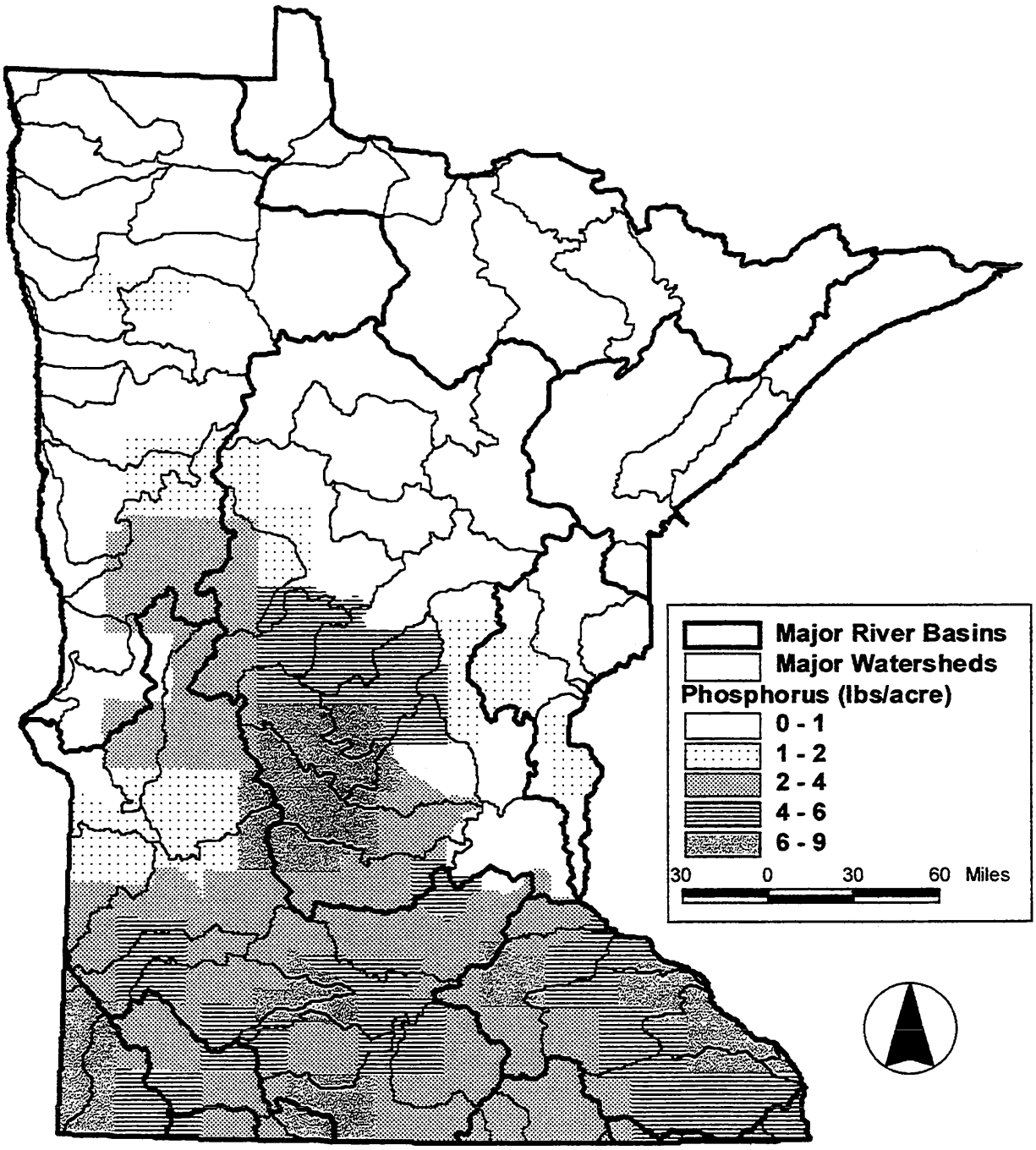
Fig. 22: Phosphorus Content of Manure Produced Per County Acres



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It is interesting that spatial patterns in nutrient content of human waste (Figs. 23-24) show some similarities with the spatial patterns in animal waste nutrient content. Human wastes are relatively important in the area running along Interstate 94 from nearly Alexandria to St. Cloud through the Twin Cities. They are also important in southeastern Minnesota. Unlike animal waste, human waste is relatively important in northern Minnesota, especially the Duluth area, the Leech Lake region, and central and northern portions of the Red River basin.

Migratory Wildfowl

Minnesota is fortunate to provide habitat and flyways for many types of migratory waterfowl. These waterfowl often spend several months breeding and feeding in Minnesota lakes, reservoirs, rivers, streams, ponds, wetlands, and ditches. According to the Department of Natural Resources, in fall of 1998 there were 7.9 million waterfowl that migrated through Minnesota. These included 7.3 million ducks of various types and 600,000 geese and swans. Assuming that geese and swans have twice the weight of ducks, and twice the daily output of nitrogen and phosphorus (from Table 47), we estimate that these migratory ducks produced 16 tons/day of nitrogen and 8.7 tons/day of phosphorus. Geese and swans produced 2.7 tons/day of nitrogen and 1.4 tons/day of phosphorus. This gives a total of 18.7 tons/day of nitrogen and 10.1 tons/day of phosphorus at peak water usage times of the year.

The key uncertainty in estimating the total impacts of migratory waterfowl on water quality is the time they spend in water. Manny et al. (1994) studied impacts of waterfowl on lakes and reservoirs in Michigan. They found that waterfowl inhabited a lake much more frequently in the months of March, October, November, and December than any other months. They estimated that wildfowl accounted for 27% of all the nitrogen and 70% of all the phosphorus entering the lake from external sources, causing serious degradation of water quality. Usage patterns decreased as the birds migrated to other locations, and were particularly low during the months of May and June.

Using survey numbers from Manny et al. (1994) for the time spent by migratory wildfowl in water during different months, and adjusting the daily maximum production of nitrogen and phosphorus by Minnesota migratory wildfowl for these changes in usage, we estimate that migratory wildfowl in Minnesota excrete 2,987 tons/yr of nitrogen and 1,613 tons/yr of phosphorus. At this time, insufficient information is available to specify which waterbodies receive these nutrients. Nutrients generated by Minnesota migratory wildfowl are 24% of the nitrogen discharged by wastewater treatment plants in the Twin Cities and upstream, and 50% of the phosphorus discharges by humans.

Fig. 23: Nitrogen Content Excreted by People Per County Acres

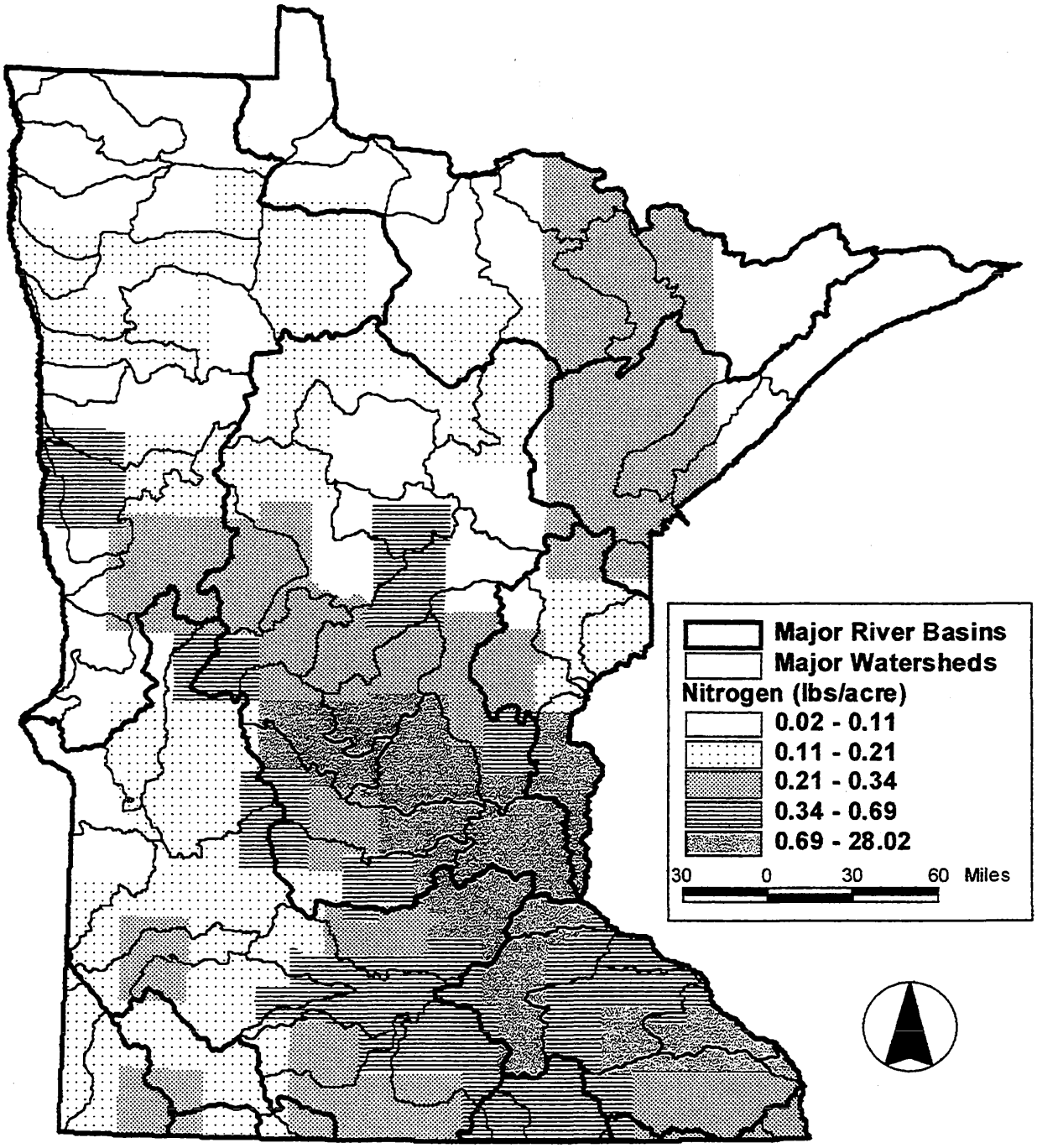

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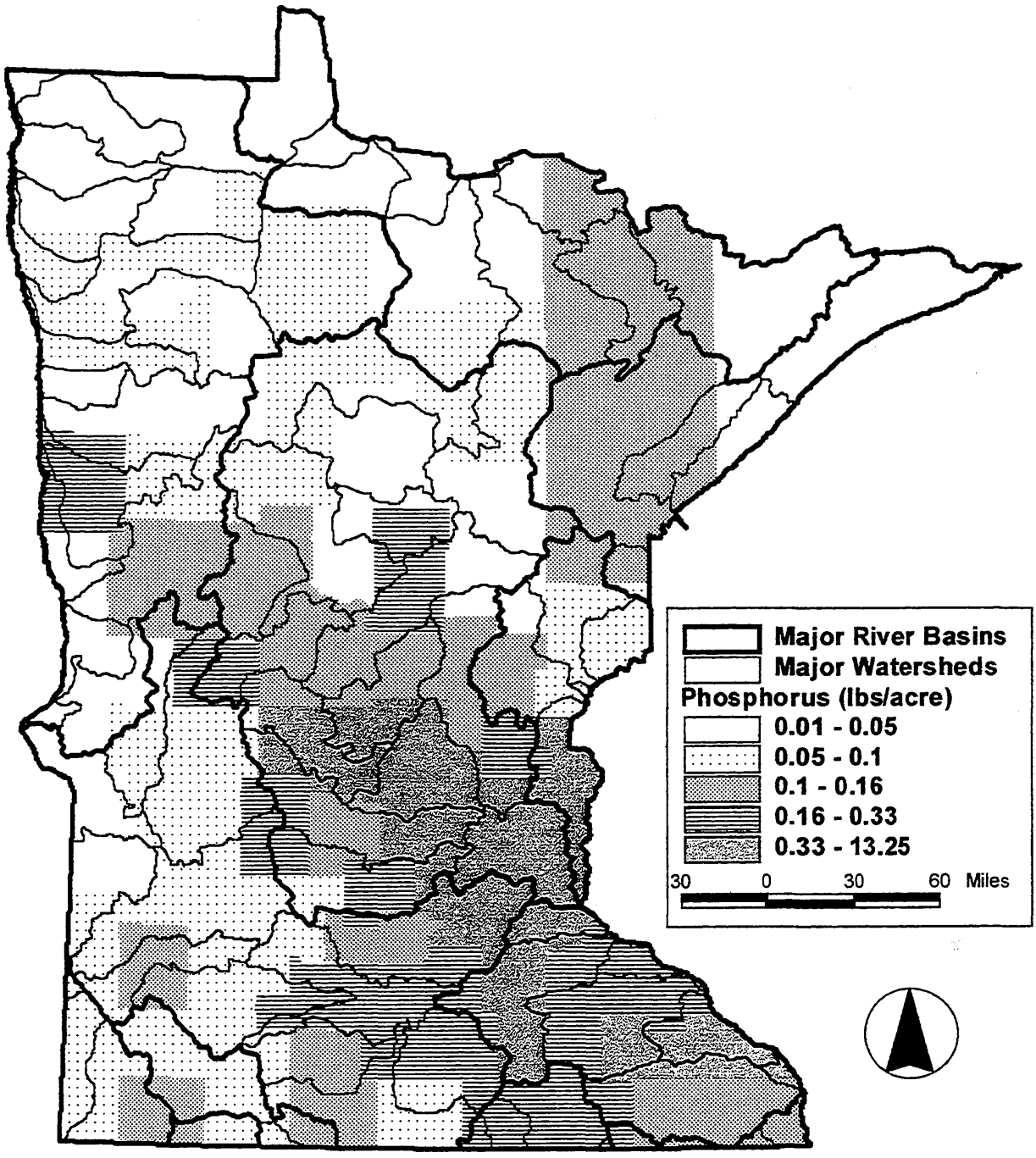
Fig. 24: Phosphorus Content Excreted by People Per County Acres



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Fertilizers

Fertilizer sales are summarized by the National Agricultural Statistics Service for every county in Minnesota. For 1996, total sales of fertilizer amounted to 729,702 tons of nitrogen and 130,866 tons of phosphorus. The nitrogen fertilizers represent 3 times the nutrient content of manures excreted by livestock in Minnesota, while the phosphorus fertilizers represent 2 times the nutrient content of livestock manures.

Spatial patterns in fertilizer sales (Figs. 25-26) are quite different from the patterns in manure nutrient production (Figs. 21-22). Nitrogen and phosphorus fertilizer sales are greatest in a band starting at the north end of the Red River basin and extending southward into west central Minnesota. From there, the band of heavy fertilizer sales extends into south central Minnesota. Lower quantities of fertilizer are sold in the areas with the greatest production of nitrogen and phosphorus in manures, namely the areas of southeastern Minnesota, central Minnesota, and southwestern Minnesota. This may indicate that partial credits are being given for the nutrient content of manures when fertilizer recommendations are being made. In the case of phosphorus, it may indicate that naturally high soil phosphorus levels in southeastern and central Minnesota (Montgomery and Legg, 1993) are being accounted for when making a phosphorus fertilizer recommendation. Survey data collected by the Minnesota Department of Agriculture (Montgomery and Legg, 1993) suggests, however, that farmers are still over applying nitrogen fertilizers when manure is spread on the land.

The amounts of nitrogen fertilizer sold are not necessarily a good indication of the amounts available for crop uptake and losses by leaching and runoff. Up to 10% of the applied nitrogen fertilizer can be lost by volatilization of ammonia (Burkhart and James, 1999). Significant quantities of nitrogen fertilizer can also be lost to the atmosphere by denitrification.

Recycled Sources of Nitrogen

Nitrogen is naturally supplied to soils and crops by recycling of the nitrogen applied to land from fertilizers and manures, or in the form of nitrogen fixed from the atmosphere by legumes. By far the most important source of recycled nutrients is soil organic matter. Minnesota soils have large amounts of organic matter, county-wide average organic matter contents range from about 3% to over 30%. Each percent of organic matter can produce 20 lb/ac of nitrogen on cultivated land. Using this approach, we estimate that the production of nitrogen by mineralization of soil organic matter on cultivated lands in Minnesota amounts to roughly 946,000 tons of nitrogen per year. This is equivalent to the total amount of nitrogen in purchased nitrogen fertilizers plus the nitrogen content of excreted animal manures. Once released from soil organic matter, mineralized nitrogen is available for crop uptake, leaching, or losses in runoff. Spatial patterns in mineralized nitrogen (Fig. 27) show the greatest amounts generated in the northern Red River basin, and in the south central region of Minnesota.

Fig. 25: Nitrogen Fertilizer Sold Per County Acres

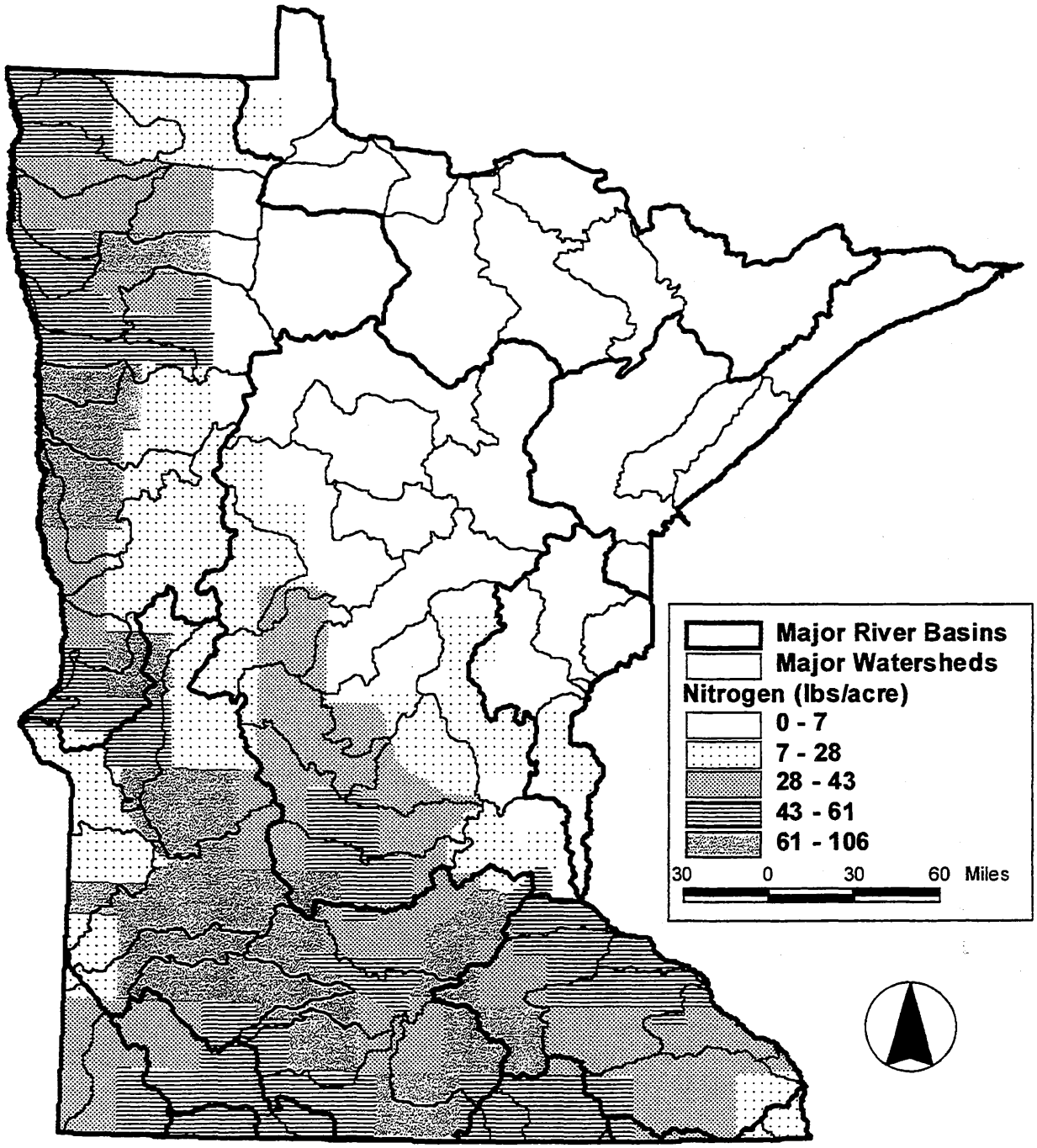

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Fig. 26: Phosphorus Fertilizer Sold Per County Acres

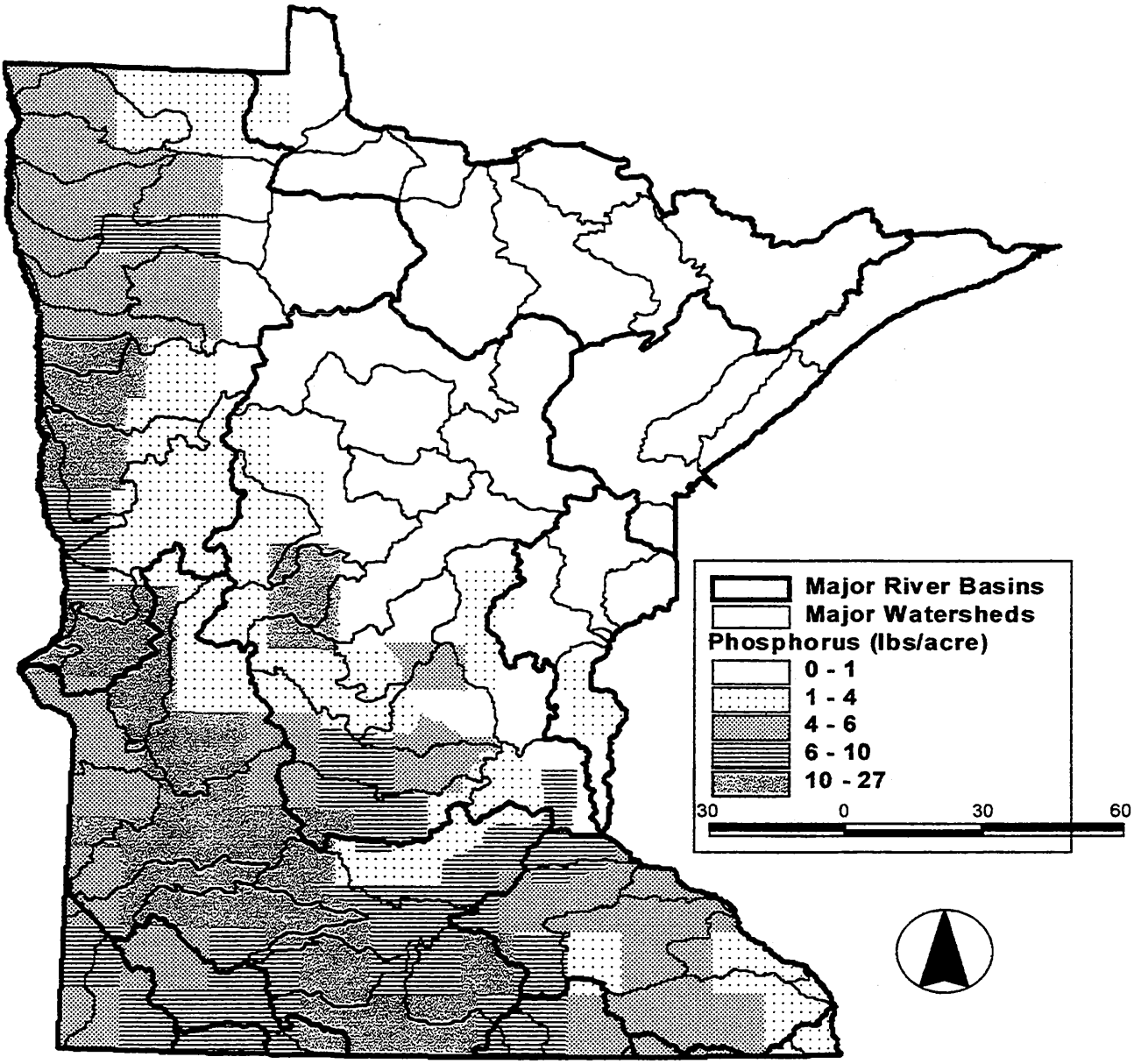

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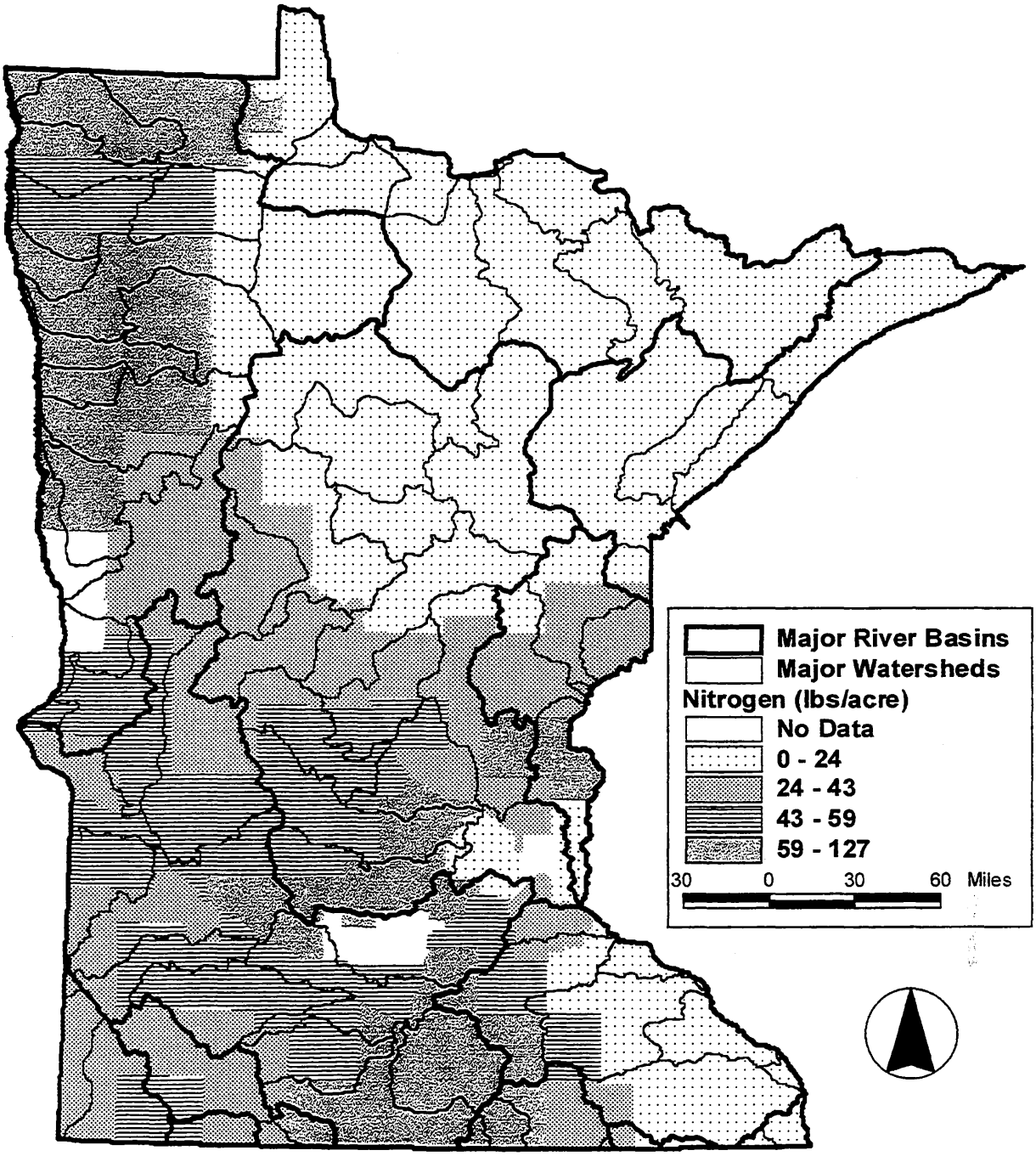
Fig. 27: Nitrogen Credits for Organic Matter Per County Acres



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Another source of recycled nitrogen is fixation from the atmosphere by legumes such as soybean and alfalfa. The amount of nitrogen available for crop uptake and transport to surface or subsurface waters after fixation is estimated at 40 lb/ac for soybeans and 100 lb/ac for plowed down alfalfa. Accounting for the county-wide acreage in soybeans and alfalfa, we estimate that the annual nitrogen credits from these two crops are 123,000 and 36,000 tons of nitrogen, respectively. These amount to roughly two-thirds of the nitrogen excreted in animal manures. The spatial patterns for nitrogen credits from soybean and hay are quite different. The spatial pattern for soybean nitrogen credits (Fig. 28) shows the greatest amounts in counties of central and southwestern Minnesota. The spatial patterns for hay nitrogen credits (Fig. 29)are most important in southeastern and central Minnesota, following the pattern in dairy cattle population densities.

Another source of nitrogen is residual nitrogen carried over in the soil from the previous cropping year. This credit is normally only important in dry climatic regions along the western edge of Minnesota. The magnitude of this credit is about 50 lb/ac nitrogen from cultivated lands. We estimate that roughly 129,000 tons of nitrogen are supplied in dry western Minnesota counties by residual soil nitrogen. The spatial distribution (Fig. 30) is heavily weighted towards southwestern Minnesota and the Red River basin.

Finally, there is considerable atmospheric deposition of nitrogen. Montgomery (1991) estimated that this generates 134,000 tons of nitrogen per year in Minnesota. This does not include redeposition of locally derived ammonia resulting from the volatilization of nitrogen in manure storage lagoons. Burkart and James (1999) estimated that this source is roughly 5 times greater in magnitude over southern Minnesota than the amount from atmospheric deposition. The state-wide contribution from this source is not available at this time.

Table 49 summarizes the findings of this section. It is not possible at this time to estimate the proportional (or percentage) contribution to nitrogen and phosphorus loads in Minnesota surface waters from these sources. For example, the nitrogen and phosphorus arising from migratory wildfowl and human waste is largely discharged directly into water. In contrast, the nitrogen and phosphorus from fertilizers are applied to the land, and only a small percentage enters surface waters. The nitrogen from animal manure is subject to a variety of losses during storage, handling, and application which affects the total amount of nitrogen applied to land from manures. In addition, only a fraction of the nitrogen and phosphorus in land applied manure enters surface waters by runoff, erosion, and tile drainage.

Fig. 28: Nitrogen Credits for Soybean Per County Acres

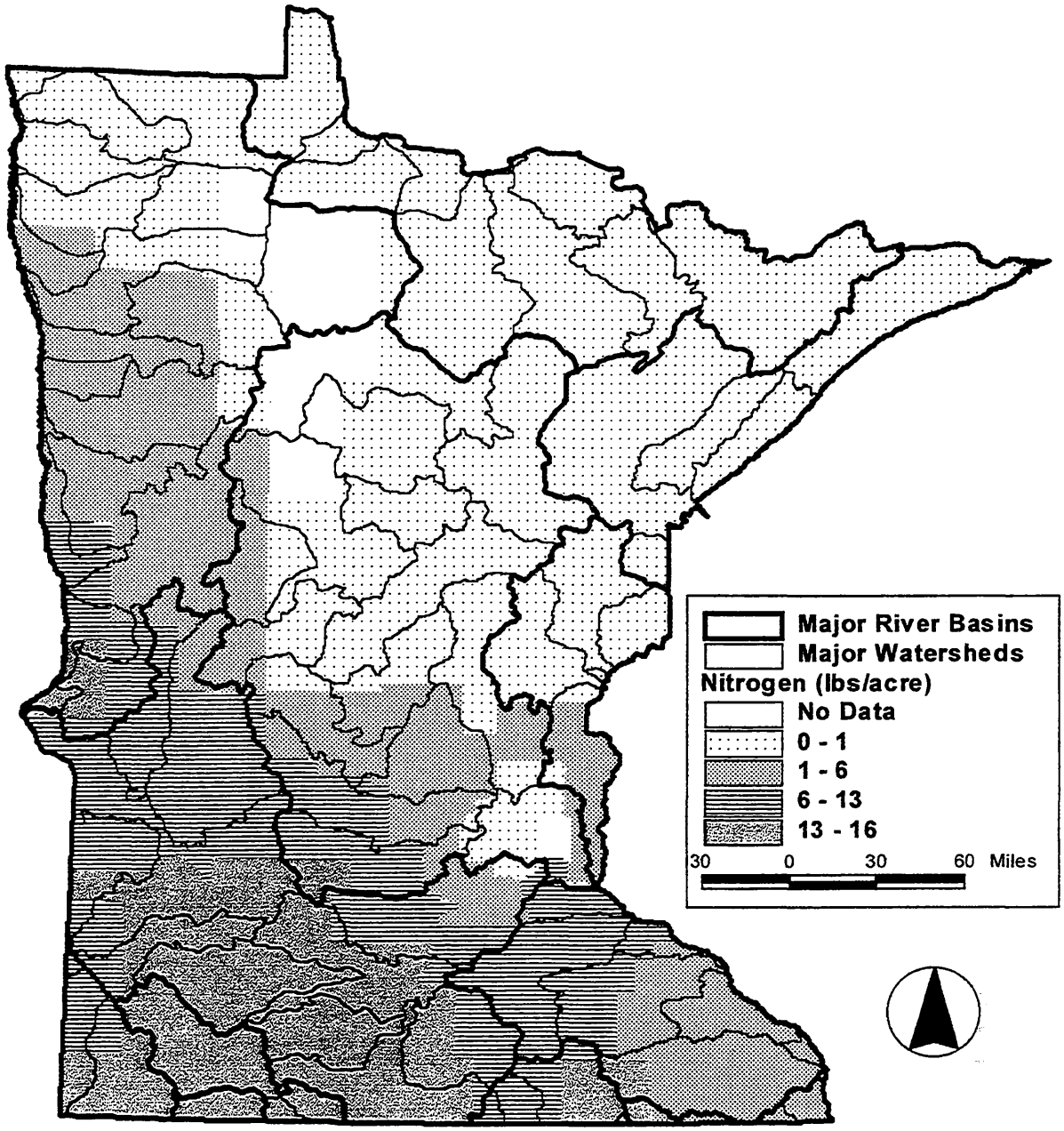

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Fig. 29: Nitrogen Credits for Hay Per County Acres

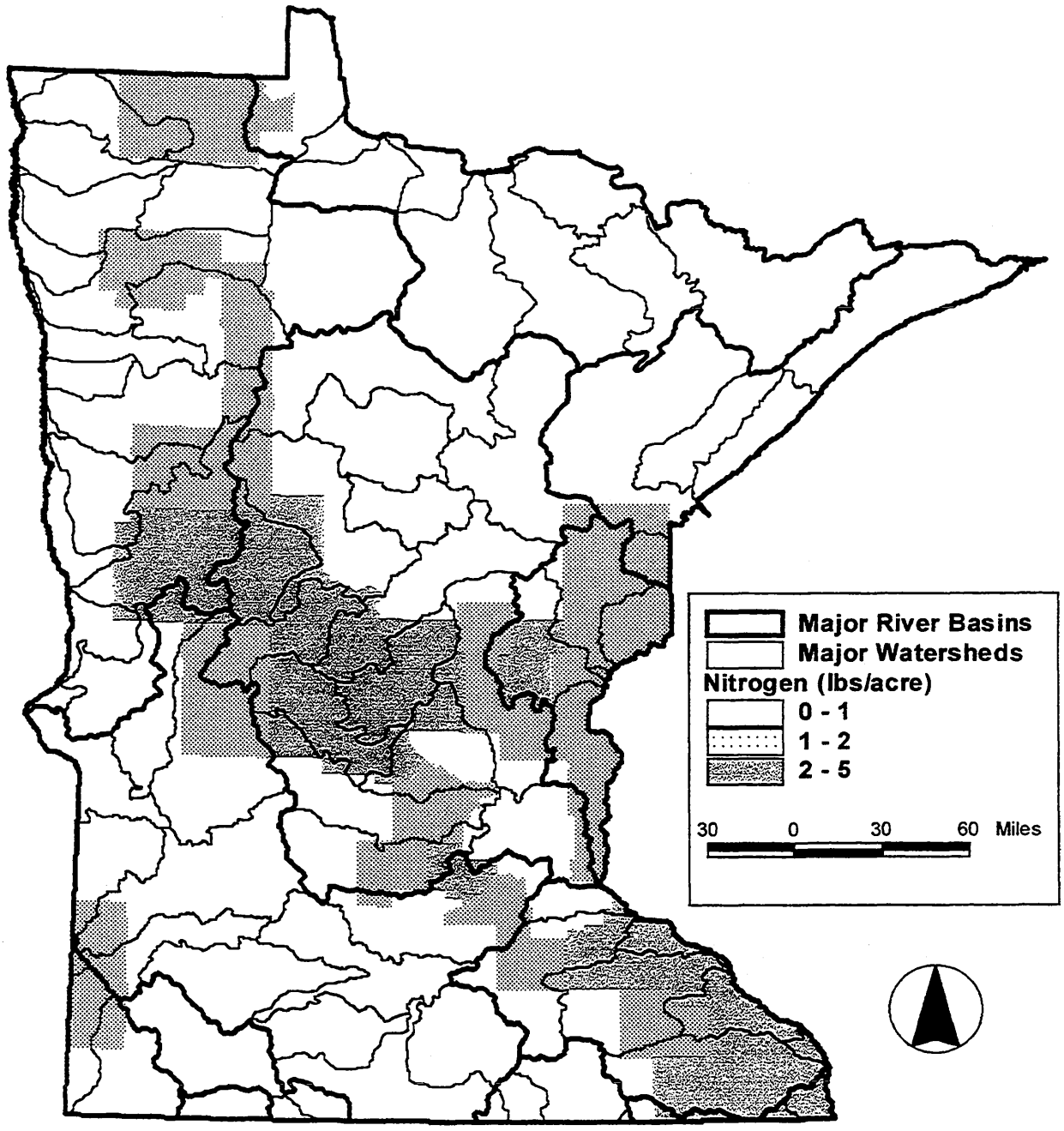

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Fig. 30: Residual Soil Nitrogen on Corn and Wheat Land Per County Acres

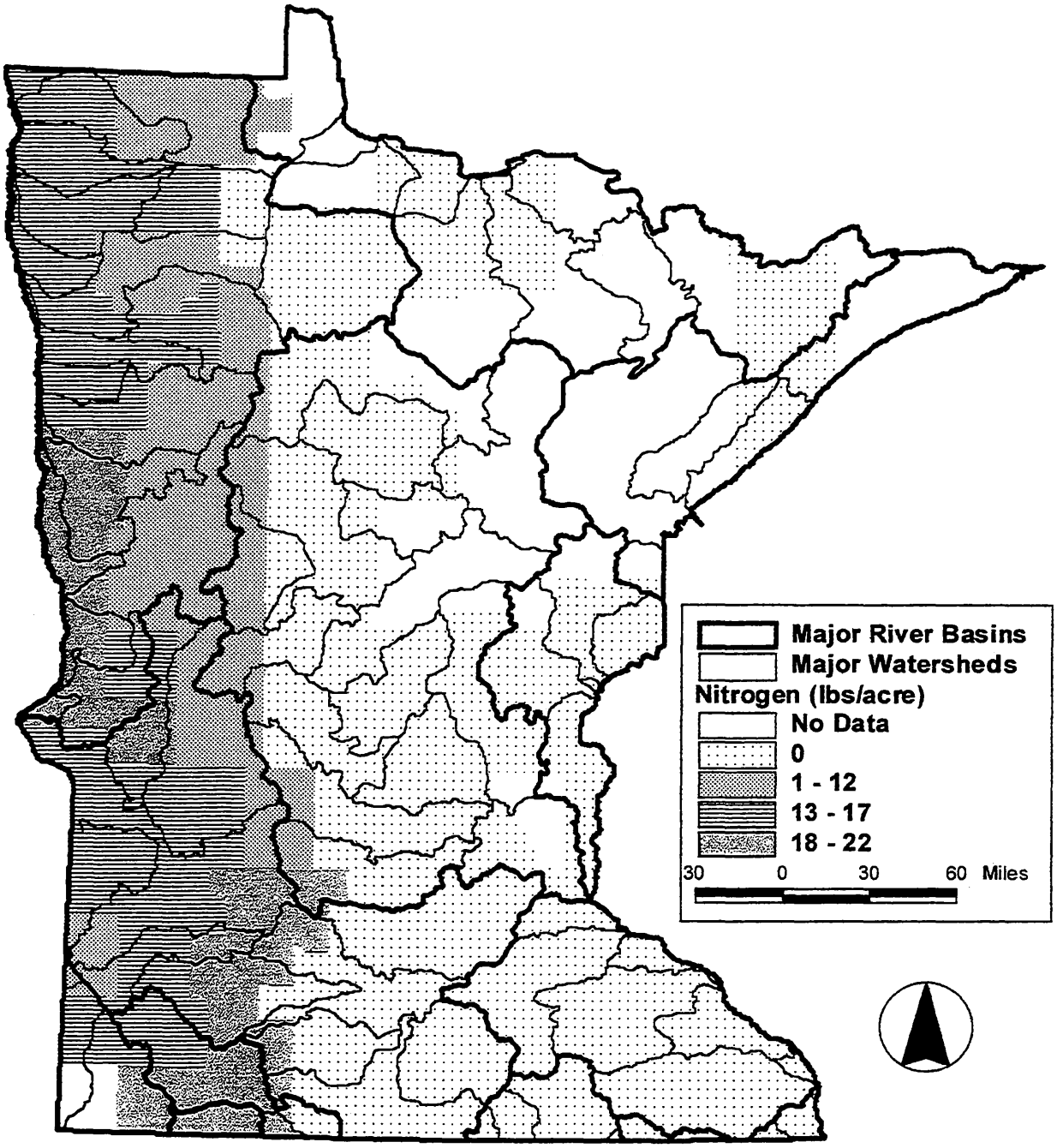

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Table 49: Minnesota Estimates of Nutrient Production From Various Sources

Source	Total Nitrogen	Total Phosphorus
	----------U.S. tons/yr----------	
Excreted Animal Manure	244,566	65,862
Excreted Human Waste	14,503	6,855
Migratory Wildfowl	2,987	1,613
Fertilizer Sales	729,702	130,866
Soil Organic Matter	946,577	- - - -
Various Nitrogen Credits	288,322	- - - -
Atmospheric Deposition	134,000	- - - -
Crop Removal by Harvest	879,500	197,700

Nutrient Budgeting Concepts

The sources of nutrients must be counterbalanced by their sinks using a nutrient budgeting or mass balance approach. Van Horn et al. (1996) showed that whole farm nutrient budgets are a useful approach for improving the efficiency of nutrient use and reducing environmental losses. The four main components of whole farm nutrient budgets include excrement, plant removal, nutrient losses, and off-farm export. They constructed a mass balance evaluation for a specific dairy farm to illustrate the recycling of nutrients from fertilizer and manure through crops, and the types of components that must be considered. Surface runoff and ground water leaching represent very small losses in the nutrient budget.

The major sinks for nutrients applied to cropland include removal of nutrients in harvested plant material, volatilization of nitrogen due to crop death and decay, volatilization of manure and fertilizer nitrogen, soil denitrification losses of nitrogen gas, and immobilization in soil organic residues (Burkhart and James, 1999). The difference between sources and sinks represents the amount available for leaching, runoff, and storage in soil.

We have been able to estimate only one of the above nutrient sinks, namely; the removal of nutrients in harvested plant material. This was achieved by using plant material nutrient removal values from Havlin et al. (1999), along with statistical data for crop yields of corn, wheat, soybean, and alfalfa in Minnesota counties. Amounts removed by harvest are estimated at 879,500 tons of nitrogen per year and 197,700 tons of phosphorus per year. The amount of phosphorus removed at harvest is nearly equal to the combined amounts of phosphorus from fertilizer and animal manure, suggesting that very little excess phosphorus is available for losses to the environment. Spatial patterns in crop nutrient removal (Figs. 31-32) show the greatest removal rates in south central Minnesota, with decreased removal rates in central and southeastern Minnesota where the nutrient contents of animal manure are greatest (Figs. 21-22).

An evaluation of the total nitrogen budget is much more difficult than that for

phosphorus. At this time we do not have values for some of the major sinks of nitrogen as outlined above. Using what is known, the amount of nitrogen removed at harvest is roughly 10% less than the amount potentially available in fertilizer and excreted manure. Since significant losses of nitrogen from manure can occur by volatilization during storage, handling, and application, the amounts of nitrogen removed at harvest are probably quite close to the total amount of nitrogen available for crop uptake from fertilizers and manures. When other nitrogen sources such as soil organic matter, various nitrogen sources and atmospheric deposition are considered, there is a clear state-wide excess of nitrogen applied as fertilizer and manure. We do not know if the unaccounted for nitrogen sinks would balance the excess at this time.

Fig. 31: Nitrogen Removal by Harvested Crop Per County Acres

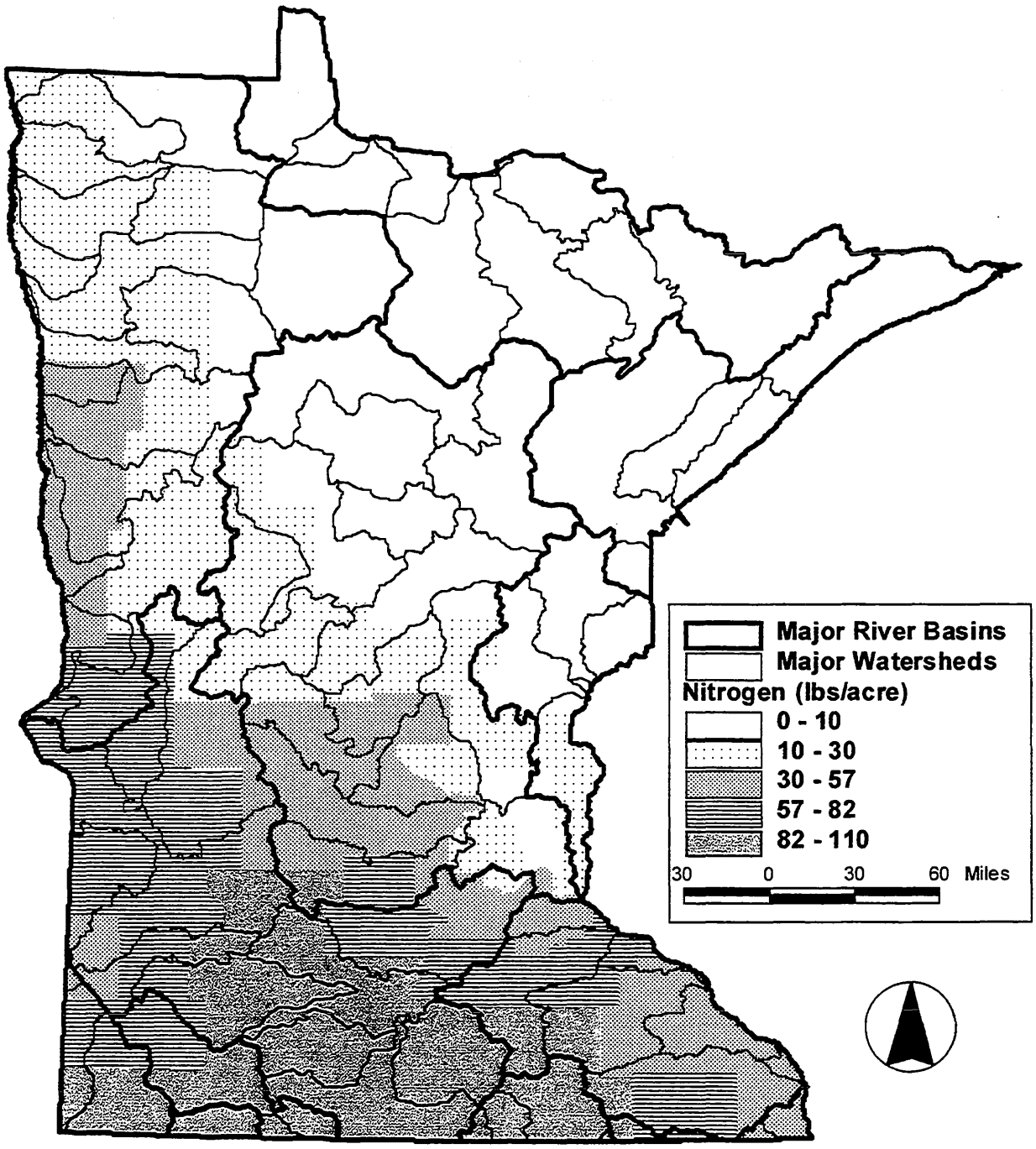

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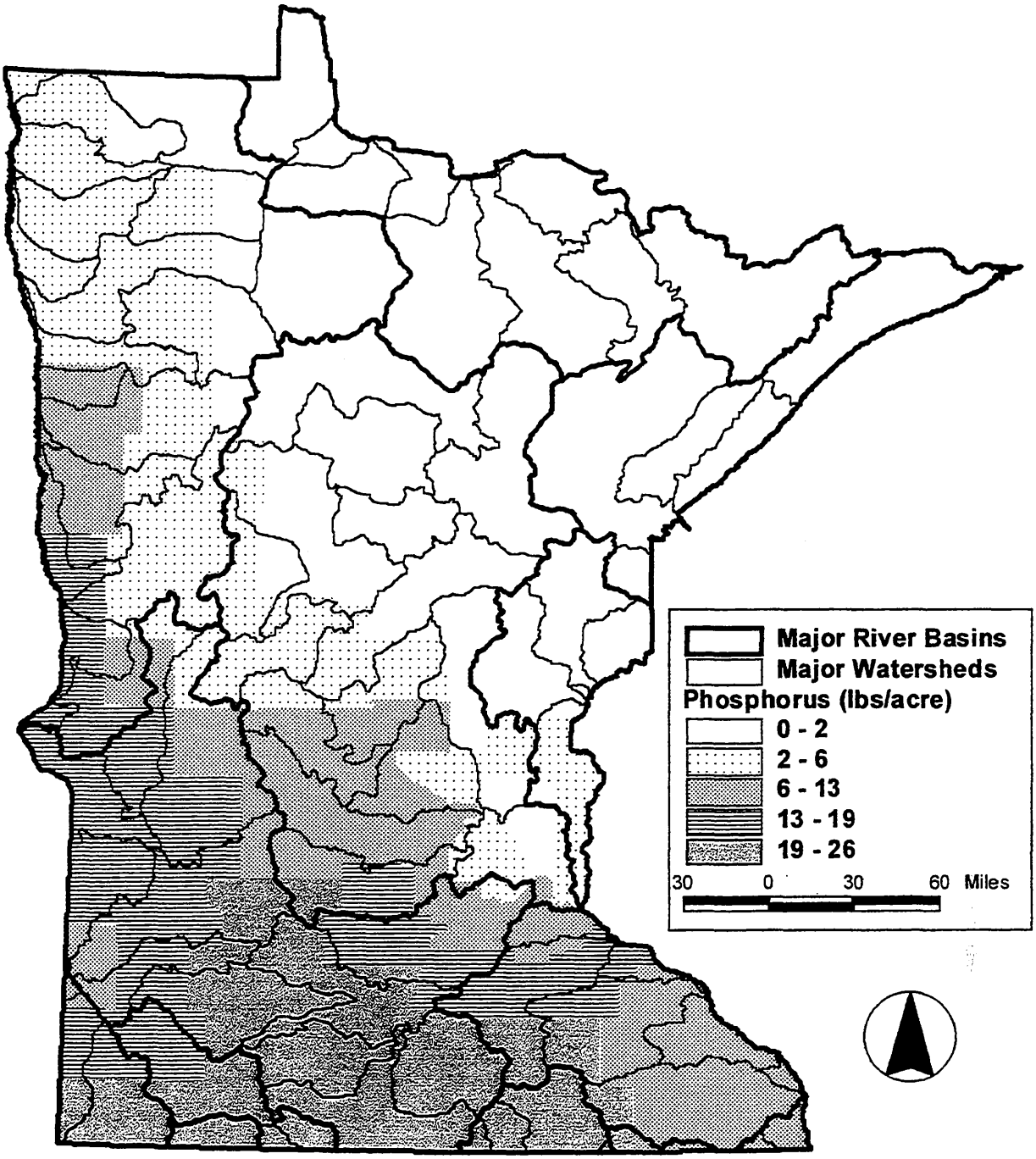
Fig. 32: Phosphorus Removal by Harvested Crop Per County Acres



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Recommendations for additional research

Research on Sources of Pollution

- What are the total loads of phosphorus, nitrogen, and sediment in major watersheds of Minnesota's nine river basins? This information is needed to understand the potential percent contribution to these loads from animal agriculture.

- A statistical analysis relating Minnesota's animal densities, land use patterns, climate, soil and sediment properties, river channel hydrologic characteristics, depth to ground water, and surface or ground water quality impairment would be useful for identifying the specific contributions of animal agriculture to water quality impairment.

- There is a critical need to identify the surface waters of Minnesota which are most vulnerable to phosphorus, nitrogen, and pathogen pollution arising from animal agriculture. Models such as the phosphorus index approach could be used in this effort using geographic information sytems (GIS) analysis of state-wide patterns in animal manure production, fertilizer sales, landscape slope steepness, soil permeability and drainage status, and density of stream networks.

- There is a critical need for further research on methods for identifying sources of pathogens in Minnesota rivers.

- More research on hormones, metals, and pesticides in runoff from land applied manure is needed.

- A thorough analysis of nutrient budgets (inputs, outputs, sinks, and losses to the environment) for animal agriculture is needed at the farm scale for individual types of animal operations. A state-wide analysis of nutrient budgets using county level information would also be instructive in determining the potential losses to the environment of nutrients from animal operations. This analysis could also be useful in comparing the impacts on surface water quality of animal wastes versus wastes from fertilizers, wildfowl, and humans.

- No research is available in Minnesota to identify the extent of local redeposition of nitrogen after ammonia is volatilized from manure storage basins. Similarly, no research is available to identify the magnitude of nitrogen losses to the atmosphere by losses during crop senescence. In national studies, these two pathways for nitrogen losses to the environment have been assumed to be very important in Minnesota without any local data to support these assumptions.

- The temporal variation in nutrient loading to surface waters from wildfowl is poorly understood.

- Further study of endocrine disruption resulting from animal agriculture is needed, along with

tools to better understand any impacts and their significance.

- Research is needed to determine how the age of a feedlot affect its potential for pollution of surface and ground waters.

- Research is needed to determine how runoff and erosion vary with the type of feedlot and its site characteristics.

- Research is needed on the variation across the state of Minnesota in local water usage patterns by animal agriculture in comparison to local water availability from precipitation, and surface or ground waters.

- Research is needed on the impacts of animal agriculture on water quality in Lake Pepin and the Lower Minnesota River between Jordan and Ft. Snelling relative to other sources.

Research on Best Management Practices for Water Quality Remediation

- An analysis of the trade-offs and impacts on water quality from reducing ammonia volatilization in manure storage basins is needed.

- Better methods (e.g. wetlands) are needed for treating liquid animal manure to reduce the nitrogen, phosphorus, and pathogen content before the manure is applied to land. Many options for such treatment are available for solid manure (composting, alum additions, etc.), but the options are limited for liquid manure.

- The impacts on water quality of dietary modifications in animal feed (reductions in nitrogen and phosphorus, phytase additions, etc.) should be rigorously studied.

- More information is needed on the effectiveness and length of time required for watershed restoration efforts in reducing lake and stream pollution from animal agriculture.

- Improved equipment is needed for accurate control of manure application rates on land.

- The impacts of surface tile intakes on delivery of phosphorus from animal manure to surface waters are poorly understood.

Research on Human Health Impacts of Pathogens

- What public health risks from pathogens exist in surface waters used by 1 million residents of the Twin Cities metropolitan area?

- Study is needed of the factors affecting survival of pathogens, especially animal viruses, in manure and in the environment.

- Development of rapid methods is needed for the concentration and detection of animal viruses from large amounts of water, soil, and manure.

- Development of accurate relationship between pathogens (viruses and protozoa) and indicators of pathogens (bacteria) in surface waters is needed.

Research on the Impacts of Animal Grazing on Water Quality and Stream Habitat

- Further research on animal grazing practices (conventional pasture, rotational grazing) is needed in Minnesota to identify the water quality impacts of grazing, especially the issues of livestock exclusion and riparian protection in rotational grazing systems. Rapid assessment tools are needed to evaluate the impact of grazing on stream water quality. Research is also needed to evaluate the potential impacts on water quality from expanding the acreage of land in grazing operations, while reducing the acreage of row cropping systems.

- Baseline data on grazing impacts on water quality and habitat should be collected in a spatially relevant framework (e.g., in the context of agroecoregions and stratified on the basis of livestock management intensity). Development of a predictive macroinvertebrate monitoring tool is needed which would be based on that base line data.

Research on Policy Issues Related to Water Quality Impacts of Animal Agriculture

- What chlorophyll a levels should be used as an indicator of water impairment? Similarly, what levels of total phosphorus and bioavailable phosphorus in rivers are useful goals for cleanup strategies?

- Research is needed to identify the scientific basis for setting critical soil test phosphorus threshold levels on a variety of Minnesota soil types. This would include study of the factors affecting bioavailability of phosphorus from manured soils, study of phosphorus sorption and desorption from various soil types in Minnesota, and evaluation of algal biomass produced in runoff from various locations.

- Studies on the relationships between animal densities and land available for manure spreading are needed in Minnesota to help determine the critical animal density beyond which significant impairment of surface or ground water quality occurs.

- Incorporation of both assessment and monitoring information in a watershed, landscape and cumulative effects context is needed, allowing decision makers to understand the broader implications of policy actions.

- Research should be conducted so that the state-wide generic environmental impact statement on animal agriculture would be able to address the following information:

1. How is animal agriculture actually practiced today in Minnesota? That is, an initial county-

level feedlot study (named the "Part A" study for this document) should develop a standard feedlot inventory. The inventory should be used to comprehensively determine:

a. How many animal feeding operations are there in each county, watershed, etc.? Where are they located?

b. What are their respective sizes? What types of feedlots are they? What livestock do they raise?

c. Who owns the operation? Do they have an MPCA permit?

d. How is each facility managed, including how does each facility manage its animal wastes?

e. What runoff, if any, escapes and may be enriched from the animal waste? Is there any nutrient- or pathogen-enriched water recharging to the groundwater? (The latter question would be answered "yes" if there is obvious leakage/seepage into the ground; otherwise, if there is nothing visible, the only other possible answer from a site visit is "don't know". An accurate water balance evaluation, including careful measurements, would be required to provide any other answer, such as the quantitative amount of leakage, or that there is no leakage, because leakage to groundwater is usually an 'invisible' problem).

f. Are there any abandoned feedlots, or old, open or partially open feedlots that no longer have animals compacted the soil daily within the lot? If any of these exist,
   i. where does the runoff go? how much?
   ii. is nutrient- or pathogen-enriched water recharging to the groundwater?
   iii. what types of low cost practices can be utilized to correct the majority of these open lot scenarios?
   iv. if the best solution involves moving the feedlot or installing very expensive pollution control measure, who pays? is there any funding source that could be identified, to help the landowner take that step?

g. Where are all nearby (private and public) water supply wells located, including the on-farm wells and wells on surrounding properties (say, within a 2-mile radius, and include drinking water wells and irrigation wells)? Determine the following for each:
   i. What are the well depths, well ages, pumping capacities of each well, and from which aquifer(s) are they drawing water? Are there any records available from well installation?
   ii. For each well, has it had any known maintenance? Are there any records available from the repair work?

h. What is the environment each facility is located in, including the following: regional information on soils, geology, and hydrogeology (including interactions of surface waters and groundwaters with soils and bedrock, and how does it fit into the regional-scale

geology and water systems)? Especially important are the careful characterization of sensitive geologic areas, where there is little or no protection of aquifers from land use impacts, including:

i. the karst area of southeastern Minnesota, where groundwater flows in solutionally-enhanced fractures and surface waters directly connect to groundwater via sinkholes, sinking streams, springs, and other types of flow;
ii. other areas in Minnesota with significant groundwater flow through fractures;
iii. the sand plains (glacial outwash areas) of Central Minnesota, and especially those areas with a history of irrigation agriculture that enhances surface water drawdown;
iv. areas of alluvial sands (deposited by old meandering streams), which are typically of limited spatial extent, especially areas such as in southwestern Minnesota where the underlying crystalline bedrock does not provide any alternative aquifers;
v. other areas with enhanced surficial permeability (such as scattered sand and gravel deposits), where rural residents often use shallow sandpoint wells for their drinking water. (These can sometimes be detected by examination of geology resource maps which show existing and abandoned sand and gravel mines).

The inventory for feedlots should be developed so it can take advantage of existing knowledge in each county, and prevent duplication of effort. According to Mr. Terry Bovee and Mr. Mike Howe (Planners for the MDH Source Water Protection program), most counties have conducted some level of feedlot inventory for their Comprehensive Local Water Plan (the so-called "319" CLWP plans developed by each county, in coordination with the Board of Soil and Water Resources); however, all but a handful of counties have done a very preliminary type of study.

A Level I CLWP feedlot inventory is simply the locations of feedlots in the county (the same as question 1.a., above). A Level II inventory also investigates the information listed in questions 1.b. and 1.c. The highest level, Level III, additionally includes the information in question 1.d., and in questions 2.a., 2.j., 2.k., and 2.l (below). So far, most counties have used MPCA feedlot block grants or BWSR water plan block grant dollars to perform their inventories. The coordination of the proposed inventory for the GEIS, with the local County Water Planners and the MDH Source Water Protection program, will leverage available dollars to provide information for all three purposes (the CLWP, the Source Water Protection plan for each PWS, and for this GEIS study).

2. Using the information from Part A study (question 1, above) within each hydrogeological region, a stratified random sampling of livestock facilities (including the entire range of operation types and sizes) should be performed to determine impacts on water (a "Part B" investigation). This second, regional level of investigation must consider all potential impacts to surface waters and groundwaters. In a review of information on nitrate in groundwater in Wisconsin, a panel of experts from diverse disciplines has concluded that, on a statewide basis, about 90% of the nitrate detected in groundwater is from agricultural sources (fertilizer, manure, and legumes). Septic systems and other sources were shown to only contribute 9% and 1% respectively.

To get the most information about impacts to water, the randomization of livestock facilities should be employed after initially choosing those facilities with good information on well characteristics (age, depth, aquifer, etc.). (A second tier of randomization may need to be done for facilities without good well information; it is likely they would be biased toward older and/or smaller facilities, which may have significantly different impacts to the environment.) The Part B investigation must evaluate each different major hydrogeologic region, and should study the following:

a. How does each facility store, remove, and sell and/or apply all animal wastes generated on the farm?

b. For their manure storage system(s)(lagoons/basins, pits, manure packs, etc.), what are the ages of the systems, designs (earthen unlined lagoon, clay-lined lagoon, synthetic-lined or concrete-lined basin, etc.), history of maintenance, etc.?

c. Does the storage system have perimeter tile drainage? Where are all drainage tiles on the farm located? Can a sampling system be installed to study water quality parameters, and changes in those parameters over time, (to help address the question of how much leakage there is from the animal waste storage system)?

d. Could there be any old, unknown tiles beneath, or adjacent to, the lagoons, pits, etc. which could enhance underground leakage? (Old but forgotten drainage tiles have been found in Iowa, after livestock facilities were built, and the tiles were later determined to provide direct, but invisible, connections to groundwater because old tile lines frequently leak).

e. What evidence, if any, demonstrates whether, and how much, chronic leakage there is to groundwater or to overland runoff? (A carefully designed water budget protocol would be necessary over no less than a full year, including accurate measurements of all sources of water inputs to the manure system and water exports out to the environment, including direct measurements of evaporation off the wastewater storage lagoons, basins, etc).

f. What is the actual performance of their storage systems (lagoons/basins, pits, manure packs, etc.)? Include the following:
   i. Have they needed to repair leaks?
   ii. Were the leaks (if any) to overland runoff, surface water, or groundwater?
   iii. Has the manager followed their filling and emptying schedules?
   iv. Have they had any emergencies, and, if so, what were the conditions and the solutions?
   v. Compare similar designs of systems in different hydrogeologic areas. In some of the Iowa work, it has been proposed that even lined basins leak where the underlying sediments are permeable. (For instance, cracks develop in concrete basins from freeze-thaw heaving and chemical corrosion of the concrete; synthetic liners leak

along poorly sealed seams; earthen basins leak because of the development of worm burrows, plant roots, secondary blocky soil structures, etc). Yet where underlying sediments are relatively impermeable, earthen basins may leak only very slowly or at a negligible rate. (If these things are also true in Minnesota, the hydrogeologic setting of a feedlot may have a great deal more effect on groundwater than the actual design of the system).

g. What kind(s) of waste treatment is/are used, if any, including the entire range from no treatment, to composting, to highly-designed wastewater and solids/sludge treatment (similar to municipal wastewater treatment systems)?

h. What are the physical, chemical, and biological parameters of the final (either untreated or treated) wastewater and solids/sludge?

i. What is left over to be disposed of, if anything, and how is it treated and disposed? (For example, how are carcasses disposed? Placental debris--which may be highly infective?)

j. What are the other land use practices of each facility? Which fields get manure? Which get chemical fertilization? Are legumes used for nitrogen fixation? Which fields get a combination of these and what combination?

k. At what rates, timing, and how evenly, are manure and fertilizers spread on the different fields? How is calibration of spreading equipment really done? At what frequency (among farmers) is over-application of nutrients practiced?

l. What type of pollution control measures are in place? Do they meet all requirements, if any, of their permit conditions? Do they meet the county standards?

3. What are the measurable effects of animal wastes on the environment? For each feedlot in the stratified sampling (Part B) investigation, on-site measurements should be made on: physical, chemical, (and biological--such as pathogens--where relevant) parameters, including:

a. Ammonia emissions and atmospheric deposition (to develop a total nitrogen budget);

b. Surface waters of the surrounding streams, wetlands, lakes;

c. Groundwaters in the area, including the water quality parameters for at least the uppermost two aquifers;

d. Water quality parameters from regional-scale surface waters and groundwaters, for comparison to the local results;

e. Small-scale (local) specific information on soil types, slope, bedrock geology, hydrogeology, permanent buffer strips and grassed waterways, terracing, etc. of the farm and nearest neighbor properties, and annual information from each crop field receiving manure or chemical fertilizer, including crops grown, rotation strategy, etc.

The above two sets of questions should be used to frame a study of the actual performance of animal manure management strategies, including the performance of lagoons and waste storage systems, controlling for age, design, maintenance, leakage, etc., as well as the performance of different land application strategies of waste as fertilizer. Similar holistic evaluations of non-livestock farms, and of natural or protected areas, such as parks, should be performed in similar environments across the state, in order to determine baseline (or background--i.e., unimpacted) parameters of each environment, and as a control, to evaluate what are the resulting effects of animal feeding operations on the regional environment.

The microorganisms which exist in animal waste have been shown in numerous studies to exist at widely differing levels of organisms, and which have extremely variable viability due to any of the following:

a. changes in water quality (including loss of oxygen, increase of oxygen, temperature changes, sunlight-induced death, dessication and re-wetting, etc.);

b. time since leaving host (livestock);

c. interactions among pathogens (food web dynamics), etc.

d. other factors, which may include transport between hydrogeologic regimes (direct surface water inputs into groundwater, such as in the karst area), etc.

Some of the more recent studies suggest there may be some pathogenic organisms which remain viable for dramatically longer times or over significantly longer travel paths, and continue to be a health threat, as water moves overland as runoff, or through soils, and into surface waters or into different types of aquifers.

4. To address this potential, an additional study ("Part C") should determine:

a. Which, if any, microbiological organisms, which are pathogenic to humans, survive longer than coliforms, including fecal coliforms and E. coli (the indicator organisms currently used for evaluating public water supply systems)?
   i. Do they have a dormant stage, after which they can return to viability?
   ii. Can they survive some stressor, such as dessication, then become viable later?
   iii. What is the maximum time they can survive the stressor, and return to viability?

b. Which of these survive in different water qualities longer than the indicator organisms?

c. Which of these survive transport through different hydrogeologic regimes longer than the indicator organisms?

d. If there are pathogens which find their way into groundwater, under what conditions, if any can they remain viable long enough to emerge from a well and be a health threat? (Remember, that private drinking water wells often have no treatment at all. The water quality of all drinking water must be carefully protected, because private systems cannot be assumed to use treatment techniques.)

e. Can any pathogens be shown to remain a health threat after passing through water treatment techniques such as those required by the Surface Water Treatment Rule (SWTR)? This is a critical factor to study, to build on previous work (which has so far not identified significant health risks if SWTR treatment performance standards are met). However, this question needs continuing study because of numerous changing conditions e.g., continuing discovery of new strains of microorganisms, the emergence of new antibiotic-resistant strains, and the increasing size of vulnerable populations.

f. If there are any other microorganisms which would be more conservative indicators, can new tests be developed that would be cheap and easy to perform, similar to the coliform tests now available? (Obviously, something that is too difficult or expensive to test for would not be a practical indicator.)

g. Overall, should Minnesota consider using any other indicator organisms, either in addition to coliforms, or in place of coliforms, to evaluate pathogenicity?

5. After on-site measurements of physical, chemical, and biological aspects have been made, then models can be developed for each hydrogeologic region, to explicitly distinguish:

   a. Nutrient imports and exports (including fertilizer, crop, soil, livestock, and manure pools);

   b. Imports from fertilizer, feed, animals, etc.;

   c. Losses to surface waters and groundwaters, and the atmosphere, as well as to other regions (via export of feed or animals).

6. Such models should be used to:

   a. Simulate predicted changes in the density and distribution of livestock production, based on the regional ecosystem and present trends in agricultural management;

   b. Evaluate alternative types of livestock operations. Alternative types would be those which operate in different ways (compared to the recent trends of the concentration of livestock in progressively larger operations), including:

i. dispersal of livestock onto more farms;
ii. diversification of crops and livestock;
iii. spatially closer links between nutrients, feed, and livestock;
iv. and increasing reliance on on-farm, rather than purchased off-farm, nutrients (such as biological nitrogen fixation, more efficient nutrient cycling, etc.);

c. Predict changes to air quality, and to water quality parameters in the surface waters and groundwater systems (and therefore, to drinking water supplies). These predictions should include scenarios where the nutrient inputs are non-point sources (across large cropping areas), as well as point-sources (from accidental spills, from intentional discharges, from long-term seepage of lagoons and basins that may not be visible at the surface, etc.).

d. Predict what will be the costs to individual private well owners, and public water supply systems, if the water quality deteriorates from livestock agricultural inputs. Costs would include such items as:
   i. drilling new, deeper well(s);
   ii. hauling water, if there is no potable water available at a greater depth;
   iii. buying (or supplying) bottled water to rural families;
   iv. and any increased costs for purchased water from distant sources, if local supplies deteriorate too much (i.e., so that the water quality exceeds drinking water standards for health).

These predictions and cost analyses should be given careful attention, to understand how present agricultural trends may be externalizing waste management costs to the greater environment, and thus as a burden upon the public health. Such predictions for alternative types of livestock operations should give a basis for comparison of what options there are, to maximize the best qualities of a healthy livestock economy and a healthy environment.

Summary of Current Research

Investigators: Michael Sadowsky

Institution or Affiliation: University of Minnesota

Title of Study: Sources of fecal pollution using DNA fingerprinting techniques

Funding Agency: Legislative Commission on Minnesota Resources

Duration of Study: July 1, 1999 to July 1, 2001

Objectives: To create a database of DNA fingerprints from fecal coliform and correlate to isolates obtained from watershed areas.

Approach: We will isolate E. Coli from known animal and human sources, produce DNA fingerprints, correlate to DNA fingerprints using environmental isolates.

Progress: None.

Publications: None.

Investigators: D. J. Mulla and P. Brezonik

Institution or Affiliation: University of Minnesota

Title of Study: Bioavailable phosphorus credits in payment for pounds program

Funding Agency: Minnesota Pollution Control Agency

Duration of Study: Junel, 1998 to August 1, 1999

Objectives:

- Determine the relationship between soil physical and chemical characteristics and desorbable phosphorus for unmanured soils of the Minnesota River basin.

- Determine the relationship between phosphorus sorption saturation, soil physical and chemical characteristics, and dissolved phosphorus in runoff for unmanured soils of the Minnesota River basin.

- Determine the relationship between bioavailability of phosphorus, soil physical and chemical characteristics, and phosphorus sorption capacity for unmanured soils of the Minnesota River basin.

Approach:

- Select specific watersheds and agroecoregions for soil sampling. Identify sampling sites, sampling protocols, and experimental designs. Collect soil samples.

- Characterize soil physical and chemical properties including: organic matter content, pH, particle size distribution, Bray-1 available phosphorus, total phosphorus, calcium carbonate level, aluminum oxide and iron oxide content.

- Evaluate bioavailability of phosphorus in samples using sodium hydroxide extraction, calcium chloride extraction, iron oxide resin strips, and algal bioassay.

- Conduct experiments to determine phosphorus sorption saturation and desorbable phosphorus.
- Conduct laboratory runoff experiments to determine dissolved phosphorus content in runoff under simulated storms.

- Conduct statistical analysis to develop calibration curves between soil physical and chemical characteristics and:

    i) desorbable phosphorus.

ii) phosphorus sorption capacity.

iii) phosphorus bioavailability.

Progress:

To date we have found an excellent relationship between calcium carbonate equivalent in soil and either total phosphorus or plant available phosphorus. Phosphorus sorption capacity is also strongly correlated with calcium carbonate equivalent. Algal bioassay experiments are in progress to determine bioavailability of P from various soils.

Publications: None.

Investigators: H. Murray, D. Allan, and D. J. Mulla

Institution or Affiliation: University of Minnesota

Title of Study: Sustainable Farming Systems

Funding Agency: Legislative Commission on Minnesota Resources

Duration of Study: September, 1996 to June 30, 2001

Objectives:

- Study the economic and environmental impacts of sustainable farming systems at 8 sites in the Minnesota River basin.

Approach:

Comprehensive data from 8 on-farm research sites will be used to evaluate the impacts of alternative farming systems on the environment and on economic profitability. The farms studied include:

- Rotational grazing on pastures
- Ridge tillage in a corn-soybean rotation
- Conventional corn-soybean rotation with tree buffer strips and buried tile inlets
- Organic corn on rotationally grazed pastures
- Alfalfa fields

At each site automatic water samplers are installed to collect tile drainage from surface tile intakes and subsurface drains. Samples are being analysed for nitrate, ammonium, soluble and particulate phosphorus, bioavailable phosphorus, biochemical oxygen demand, and sediment.

Progress:

Monitoring results through 1998 show that alternative practices produced significantly less pollution of runoff and drainage water than conventional practices. Precipitation during 1997-98 in the growing seasons was below normal. A great number of runoff events have occurred during 1999 from all fields studied. The water samples from these events are currently being analysed.

Publications: None.

Investigator: D.E. Storm

Institution or Affiliation: OKLAHOMA STATE UNIVERSITY

Title of Study: DEVELOPING A RISKED BASED APPROACH TO WATERSHED/BASIN LEVEL NONPOINT SOURCE POLLUTION ASSESSMENT

Funding Agency: HATCH PROJ.

Duration of Study: 01 OCT 1997 TERM: 30 SEP 2002

Objectives: A risk-based systems approach to watershed/basin-level pollutant assessment and trading will be developed to address point and nonpoint sources of pollutants within agricultural and urban watersheds. The systems approach will integrate ecology, engineering, economics and political science to promote source water protection and address declining water quality from point and nonpoint source pollutant loading to surface waters.

Approach: The first step is to determine the pollutant loading a water body can assimilate without degrading ecological services, exceeding water quality standards, or exceeding local water quality objectives. To answer this question, a methodology for calculating Total Maximum Daily Loads (TMDLs) for nutrients and/or sediments will be developed. The next step is to identify the sources of specific pollutants within the watershed and characterize the pollutant-reduction potential for each source. The risk of exceeding a specific TMDL based on current land-use practices will be quantified using Monte Carlo simulation modeling. The final step will be to evaluate and optimize the opportunities for pollution reduction using economic cost/benefit analysis and policy compatibility modeling. These three steps will be combined into a systems approach to be applied on a watershed or basin level using a quantifiable uncertainty analysis.

Progress: Considerable progress have been made in developing methodologies to create TMDL for basins in Eastern Oklahoma. These techniques have regional and national applicability. Specifically, two new focused efforts are underway in the Lake Eucha Basin in northeast Oklahoma and Northwest Arkansas. The Objectives of the two projects are: 1) characterize N and P dynamics in four tributaries of Spavinaw by performing in-stream nutrient injection studies to evaluate seasonal impacts, compare biotic and abiotic sinks, evaluate flow regimes impacts, 2) using Matlock periphytometers, determine the in-stream limiting nutrient in Lake Eucha tributaries on a seasonal basis and assess the lotic ecosystem trophic status, 3) use stream periphyton and macroinvertebrate community structure to assess water quality in Lake Eucha tributaries, 4) characterize stream sediments and sediment-P interactions by measuring equilibrium P concentration, P buffering capacity, exchangeable P, particle size distribution, and sediment organic matter content in Lake Eucha tributaries, 5) develop recommendations for management of upland areas, 6) develop and implement a statistically valid soil sampling plan for measuring the soil test phosphorus for representative locations throughout the Oklahoma portion of the Lake Eucha basin for basin scale modeling, 7) convert SIMPLE to Microsoft NT operating system (SIMPLE, Spatially Integrated Model for Phosphorus Loading and Erosion, is a daily time step, continuous simulation, distributed-

parameter modeling system developed to estimate watershed or basin scale sediment and phosphorus loading to surface waters). 8) compile required data and predict average annual runoff volume, sediment load, and dissolved and sediment-bound phosphorus loading to the surface waters of the Lake Eucha Basin. Conduct independent SIMPLE simulations using historical rainfall data to provide an estimate of current loading and loading from a range of soil phosphorus levels. Conduct continuous SIMPLE simulations using stochastically generated rainfall to estimate long term phosphorous loading impacts resulting from a variety of litter export scenarios.

Publications:

1. Haan, C.T., D.E. Storm, T. Al-Issa, S. Prabhu, G.J. Sabbagh, D.R. Edwards. 1998. Effect of parameter distributions on uncertainty analysis of hydrologic models. Transactions of the ASAE 41(1):65-71.

2. Matlock M. D., M. E. Matlock, D. E. Storm, M. D. Smolen and W.J. Henley. 1998. Limiting nutrient determination in lotic ecosystems using a quantitative nutrient enrichment periphytometer. Journal of the American Water Resources Association, 34(5): 1141-1147.

3. Ramanarayanan, T.S., D.E. Storm, M.D. Smolen. 1998. Analysis of Nitrogen Management Strategies Using EPIC. Journal of American Water Resources.

Investigator: J.B. Swan, R.M. Cruse, and K.J. Moore

Institution or Affiliation: IOWA STATE UNIVERSITY

Title of Study: CROP AND RUMINANT SYSTEMS TO CONSERVE MIDWESTERN UNGLACIATED SOILS AND WATER QUALITY

Funding Agency: HATCH PROJ.

Duration of Study: 01 OCT 1996 TERM: 30 SEP 2001

Objectives: Evaluate alternative forage production systems in intensive cattle management. 2) Evaluate cattle response to alternative forages. 3) Evaluate forage-grain-cattle management systems that conserve soil and water quality.

Approach: Kura clover will be evaluated as a living mulch for corn production. Macronutrient and soil pH requirements of cup-plant will be determined. Yield and composition of stockpiled forages and crop residues for wintering beef cows will be determined. Performance of heifers fed cup-plant will be compared with those fed alfalfa silage. Calf production, reproductive efficiency, forage selection and forage intake by beef cows grazing in year-around systems will be determined. Preferential transport of contaminants under ridge-tillage will be determined. Effects of crop rotation on soil and water quality will be evaluated. Economic analysis of alternative management-intensive grazing systems for beef cattle operations will be developed.

Progress: To determine the level of soil erosion protection achieved with a no-tillage (NT) corn and soybean sequence on a highly erodible low organic matter silt loam soil with restricted rooting depth, the effect of previous crop and soil depth on percent surface cover after planting and on crop yield was measured at the Lancaster Agricultural Experiment Station, Lancaster, WI. Soybeans followed corn in 1995 and 1997 and corn followed soybeans in 1996 and 1998. Percent surface cover increased 0.3% to 0.4% per cm soil depth after either crop. Corn yields averaged 10.4 Mg/ha in 1996 and 11.6 Mg/ha in 1998. Soybean yields averaged 4.5 Mg/ha in 1995 and 3.9 Mg/ha in 1997. In 1995 soybean yield increased 11 kg/ha for each cm increase in soil depth to red clay residuum (R2=0.56). Crop yield was not related to soil depth in 1996, 1997 or 1998.

Publications: No publications reported this period

Investigator: B.C. Joern

Institution or Affiliation: PURDUE UNIVERSITY

Title of Study: BIOGEOCHEMICAL CYCLING OF PHOSPHORUS IN SUSTAINABLE PRODUCTION SYSTEMS

Funding Agency: HATCH PROJ.

Duration of Study: 01 OCT 1996 TERM: 30 SEP 2001

Objectives: 1. Validate a model that quantifies the amount of water-soluble P that can be leached from soils with different properties using soil profiles collected from manured fields. 2. Determine the retention of specific P compounds present in animal manure by soils with different properties. 3. Determine how feed management strategies that reduce total P excretion by swine and poultry impact manure P transformations.

Approach: Research conducted during this project period will include laboratory and field studies to validate a soil P retention model developed during the previous project period and to determine soil P retention dynamics for various P-containing compounds. Manure collected from animal feeding trials will also be used to assess the feasibility of reducing P excretion by monogastric animals using recently developed technologies. Results from this project will be used to develop a P indexing system that utilizes soil, crop, P source, and environmental factors to determine environmentally sustainable P management strategies for crop and livestock producers.

Progress: Phosphorus (P) is most often the nutrient that limits the productivity of freshwater ecosystems in the Midwestern United States. Agricultural fields can be non-point sources of P because high testing soils may release large quantities of soluble and bioavailable P via surface runoff, erosion, and leaching. Potential P based land application limits for animal manure mandate the development of simple, rapid, and reliable laboratory techniques for estimating potential edge of field losses of soluble and bioavailable P. We evaluated relationships among soil test P methods for soils with elevated P levels due to previous manure publications, and related these values to i) soluble P concentration (SPC) and bioavailable P (BAP). Of the soil test P methods evaluated, Bray P1 was most highly correlated to SPC and BAP. SPC was approximately 0.1, 0.25, 0.5, 1.0 and 2.0 mg P/L when Bray P1 exceeded 50, 75, 150, 200 and 500 mg P/kg, respectively. Amorphous Fe contents directly influence the relationship between BAP and Bray P1. We have adapted the SPC procedure for routine soil test purposes because it also is well related to BAP. The potential use of P based land application limits for animal manure has also increased the importance of optimizing animal feed P management. We evaluated the impacts of high available P (HAP) corn and phytase on P uptake and excretion by young pigs during a seven day digestibility trial. Our results show that, compared to the control diet, P uptake may be increased approximately 30 percent using HAP corn or phytase alone, but up to more than 50 percent when both phytase and HAP corn are present in the diet. Manure P excretion decreased 21, 23, and 41 percent below the control diet for the phytase, HAP corn, and HAP corn + phytase diets, respectively. This study clearly shows that diet

modifications can dramatically reduce P excretion by young pigs. Improved dietary P management strategies may be used to offset the increase in land needed for sustainable pork production if P-based land application regulations are implemented.

Publications:

1. Brokish, J.A., B.C. Joern, and T.L. Provin. 1997. Using soil properties to predict soluble phosphorus losses from Indiana soils. Agron. Abstr. P. 329.

2. Baxter, C.A., B.C. Joern, O. Adeola, and P.A. Moore. 1998. Phosphorus excretion by pigs as influenced by high available phosphorus corn and phytase. Agron. Abstr. P. 349.

3. Brokish, J.A., and B.C. Joern. 1998. Soluble and bioavailable phosphorus in soils: a methods comparison. Agron. Abstr. P. 348.

4. Baxter, C.A., B.C. Joern, and O. Adeola. 1998. Dietary P management to reduce soil P loading from pig manure. In D. Franzen (ed.) Proceedings of the Twenty-eighth north central extension-industry soil fertility conference.

5. Brokish, J.A. 1998. Threshold phosphorus levels for Indiana Soils. M.S. thesis. Purdue University, West Lafayette, IN.

6. Moore, P.A., B.C. Joern and T.L. Provin. 1998. Improvements needed in environmental soil testing for phosphorus. pp. 21-30. In J.T. Sims (ed.) Soil Testing For Phosphorus: Environmental Uses and Implications. Southern Coop. Series Bull. No. 389. (A publication of SERA-IEG 17 USDA-CSREES Regional Committee: Minimizing Agricultural Phosphorus Losses for Protection of the Water Resource).

7. Sims, J.T., R.R. Simard, and B.C. Joern,. 1998. Phosphorus losses in agricultural drainage: historical perspective and current research. J. Environ. Qual. 27:277-293.

Investigator: P.G. Hartel

Institution or Affiliation: UNIVERSITY OF GEORGIA

Title of Study: STEROIDS IN RUNOFF WATER FROM PASTURES AND HAYFIELDS AMENDED WITH BROILER LITTER

Funding Agency: NRI COMPETITIVE GRANT PROJ.

Duration of Study: 01 JUL 1997 TERM: 30 JUN 1999

Objectives: We will determine estrogen and testosterone concentrations in runoff and subsurface drainage from pastures and hayfields amended with broiler litter.

Approach: Our approach is to use an existing field site near Eatonton, Georgia, and originally designed to assess N and P losses from broiler litter - amended pastures, to measure estrogen (as estradiol) and testosterone in runoff and subsurface drainage. Each of the eight field plots is sufficiently large (0.6 ha) to determine true "edge of field" losses. Four pastures and four hayfields will each be amended with broiler litter or left unamended (control). Estradiol and testosterone will be measured in runoff or subsurface drainage by enzyme immunoassay.

Progress: Research on endocrine disrupters has virtually ignored the contribution of natural hormones to the environment from animal and human wastes. Given their quantity and potency, these androgens and estrogens have considerable potential for adverse environmental effects. For example, broiler litter (a mixture of broiler manure, bedding material, feathers, and waste feed) contains 65 ng of 17 beta-estradiol and 133 ng of testosterone per g of dry weight. In 1997, the poultry industry produced over 10 billion kg of broiler litter, 90% of which was applied to pastures and hayfields. We determined the amount of testosterone and estradiol (and their conjugates) in runoff water from six sloping (4 to 8% grade), 0.8-hectare plots, each surrounded with an earthen berm to channel surface runoff. Each plot was instrumented to record temperature, rainfall, and runoff volume. Three of the plots were hayfields and three were pastures. Background levels of testosterone and estradiol ranged from 14-19 and 40-50 ng per liter in runoff, respectively. When cattle were placed on the plots, the levels of testosterone and estradiol increased to 18-36 and 100-140 ng per litter, respectively. When grazed plots were amended with 9,000 kg of broiler litter per hectare and a runoff event occurred one day after application, levels of testosterone ranged from 63-1000 ng per liter and estradiol from 150-2300 ng per liter. Of these amounts, approximately 40 to 50% of the estradiol and 50 to 90% of the testosterone were in their free state; the remaining percentages of estradiol and testosterone were as conjugates. In a runoff event 12 days after litter application, testosterone and estradiol ranged from 42-120 and 46-100 ng per liter, respectively. By 200 days after litter application, levels of testosterone and estradiol were essentially at background levels. After 17 months without any litter application and 10 months without animals, the levels of testosterone and estradiol were at background levels and ranged from 13-19 and 50-80 ng per liter, respectively. Our research suggests that a) testosterone and estradiol may pose a serious environmental problem if runoff events occur soon after litter application; b) testosterone and

estradiol exist in variable percentages as conjugates; and c) cattle may contribute to the environmental hormone "load". Our study is the first to document estradiol and testosterone (and their conjugates) in runoff from large field plots amended with animal waste under natural conditions, and highlights the need to understand the environmental fate of these compounds.

Publications:

In Print Abstract: Finlay-Moore, O., Hartel, P.G., and Cabrera, M.L. 1999. Estradiol and testosterone in runoff water from pastures and hayfields amended with broiler litter. Keystone Symposium B5: Endocrine Disruptors, January 31-February 5, Granibakken, CA.

Investigators: Trlica, M. J.; Leininger, W. C.; Frasier, G. W.

Institution or Affiliation: COLORADO STATE UNIVERSITY

Title of Study: GRAZING IMPACTS ON INFILTRATION, RUNOFF, AND EROSION IN A MONTANE RIPARIAN ECOSYSTEM

Funding Agency: SPECIAL GRANT PROJ

Duration of Study: 01 SEP 1996 TERM: 31 AUG 1999

Objectives: Separate out effects of cattle trampling from grazing plus trampling on water infiltration, runoff, and sediment movement. Evaluate how differences in vegetation canopy and soil surface characteristics affect surface hydrology. Integrate these findings, with additional research, to define Best Management Practices for montane riparian ecosystems.

Approach: Steers will be allowed to trample or graze and trample riparian plots. A rainfall simulator will be used to create a high-intensity rainfall event over these plots, and sediment will be added to plots in overland flow. Runoff and sediment yield will be determined, and sediment migration will be measured

Progress: Agency managers are using information to design Best Management Practices for riparian filter strips** Grazing in riparian areas has often been considered to have negative impacts on soils, vegetation, and water quality. Many riparian areas are resilient and often respond favorably to management changes. Our results indicated that, even with heavy livestock grazing, sediment filtration in a montane riparian community was about 85% for a sandy loam sediment in a 10m buffer strip. The length of microchannels and density of vegetation stems were the major determinants of the filtration capacity of the buffer strip. However, runoff rates of overland flow and concentrations of nitrate-N, ammonia-N, and phosphate-P in the runoff from heavily grazed plots were much greater than from ungrazed or mowed plots. Nitrate-N, ammonia-N, phosphate-P and fecal coliform fluxes from grazed plots were 180%, 1350%, 2100%, and 2400% greater, respectively, than fluxes from control plots. Manure and urine deposited during heavy grazing increased the concentrations and fluxes of nutrients and fecal coliform bacteria in runoff water. Even with heavy grazing, the concentrations of nitrate-N and ammonia-N in runoff from grazed plots did not exceed the established EPA criteria of 10 mg/L and 5.1 mg/L (based on an average temperature of 5 C and pH of 7.5), respectively. However, the average concentration of fecal coliform from both grazed and control plots exceeded the EPA standard of 1000 CFU/100mL for secondary water contact

Publications:

1. Frasier, G.W., Trlica, M.J., Leininger, Leininger, W.C., Pearce, R.A., and Fernald, A. 1998. Runoff from simulated rainfall in 2 montane riparian communities. J. Range Manage. 51:315-322.

2. Pearce, R.A., Trlica, M.J., Leininger, W.C., Mergen, D.E., and Frasier, G. 1998. Sediment movement through iparian vegetation under simulated rainfall and overland flow. J. Range Manage. 51:301-308

3. Pearce, R. A., Frasier, G.W., Trlica, M.J., Leininger, W.C. Stednick, J.D., and Smith, J.L. 1998. Sediment filtration in a montane riparian zone under simulated rainfall. J. Range Manage.51:309-314

4. Pearce, R.A., Frasier, G.W. Leininger, W.C., and Trlica, M.J.. 1998. Sediment movement and filtration in riparian vegetation. Pp. 167-177. In: D. F. Potts (ed.) Rangeland Management and Water Resources. Proc. AWRA Specialty Conf., 27-29 May 1998. Reno, Nev

5. Alstad, K.P. 1998. Carbon and water relations of Salix as affected by browsing and hydrologic condition. M. S. Thesis. Colorado State Univ. Fort Collins, CO

6. Schenck, S.M., Trlica, M.J., and Leininger, W.C.. 1998. Restoration and recovery of a montane riparian plant community after a grazing disturbance. p. 10. In. Abstracts. Society for Range Management Annual Meeting. Guadalajara, Mexico. Feb. 8-12, 1998

7. Frasier, G.W., Trlica, M.J.and Leininger, W.C. 1998. Simulated rainfall runoff characteristics in riparian communities. p. 52. In. Abstracts. Society for Range Management Annual Meeting. Guadalajara, Mexico. Feb. 8-12, 1998

Investigators: Ribic, C. A

Institution or Affiliation: UNIV OF WISCONSIN

Title of Study: EFFECT OF ROTATIONAL GRAZING ON THE TERRESTRIAL BIRD COMMUNITY IN RIPARIAN ZONES OF SW WISCONSIN

Funding Agency: HATCH PROJ

Duration of Study: 01 OCT 1996 TERM: 30 SEP 2000

Objectives: The purpose of this study is to determine the differences in the avian community that result from using vegetative buffer strips and rotational grazing along riparian areas and to compare them to riparian areas that are continuously grazed. Specific objectives are (1) to compare the vegetation structure in the three land use practices, particularly as related to the nesting and feeding habitat requirements of grassland birds, 2) to compare the diversity and abundance of different guilds of song birds among the three practices, and (3) to compare these results with the results from a concurrent water- quality study. This study will contribute to understanding if rotational grazing in riparian areas can benefit wildlife and protect water quality while allowing farmers to use riparian areas on their farms

Approach: We will replicate each of the 3 land use practices on up to 5 farms. General criteria for selection of study sites include: (1) study sites must all be located in Wisconsin's Driftless Area to minimize differences in ground water-surface water relationships, (2) the management regime should have been in place for at least five years to allow time for system responseto the regime, and (3) the vegetative buffer strips will be located on farms that have livestock. Because this study is being done in conjunction with a water-quality study, sites will be located near headwater areas, where the stream is large enough to support a viable trout community. Other variables that will be controlled include farm size, cattle stocking rate, herd size, and adjacent land use. We will work with the individual farmers to document the characteristics of the particular grazing regime used. For each management regime, the width of the study sites will encompass the entire riparian area, defined as the area of land adjacent to the stream in which vegetation and soil type are influenced by the stream's presence, and will extend at least 100 meters from the stream edge on both sides of the stream. At the minimum, categories of data collection will include species richness, abundance and diversity of riparian bird communities and surrounding upland bird communities, and riparian and upland area vegetation sampling for habitat characteristics

Progress: Bird community composition was compared between three riparian management options as part of a collaborative project assessing the influence of land use on riparian ecosystems. Birds were surveyed in 1996-98 using standard point counts on 12 sites along cold water streams; four rotational pastures, four continuous pastures, and four grassy (ungrazed) 20m buffer strips within row crop fields. The occurrence of special concern species (savannah sparrow, eastern meadowlark, bobolink), as well as overall bird abundance and diversity were compared between the three types of land uses and between the streamside (less than 10m from stream) and non-streamside(greater than 10m from stream) areas. In addition, twenty-five lowland and twenty-five upland continuous pastures were surveyed twice each year for two years with point counts in order to assess the relative importance of lowland (riparian) pastures for grassland bird species of concern. Buffer strips supported a higher abundance and diversity of birds within the streamside area than away from the stream, in the row crops. Due to the concentration of birds within the buffer strip itself, these sites supported an overall higher diversity and abundance of birds than either rotational or continuous pastures. In pastures there was no difference in bird abundance or diversity between rotational and continuous pastures, but continuous pastures did support a greater number of species of concern. This may be explained by the fact that continuous pastures were on average ...sensitive", i.e. they are more likely to occur on larger pastures. In addition, rotational pastures tended to be located in more wooded areas, which may be unsuitable to species that prefer relatively open, non-wooded landscapes. We are continuing research on potential landscape effects on species of concern. Preliminary analyses indicated that some grassland bird species of concern were generally more likely to be present on upland pastures than lowland, riparian pastures. Grasshopper sparrows, bobolinks, and eastern meadowlarks occurred more frequently on lowland pastures, while savannah sparrows, western meadowlarks, and upland sandpipers did not prefer either upland or lowland pastures. Upland sandpipers, however, occurred only on lowland pastures that also contained adjacent upland pasture. Overall, pastures appear to be more valuable for grassland birds than buffer strips located within row crops. The type of grazing management in a pasture, however, may be less important in determining grassland bird community composition than larger-scale factors such as the pasture size and characteristics of the surrounding landscape. In general, the lowland pastures that are associated with streams do not support some species of concern as frequently as upland pastures. Focusing conservation efforts on upland pastures may therefore be most effective

Investigators: Albrecht, K. A

Institution or Affiliation: UNIV OF WISCONSIN

Title of Study: INTEGRATED CROP, SOIL, AND ANIMAL MANAGEMENT SYSTEMS FOR UPPER MIDWEST UNGLACIATED SOILS

Funding Agency: HATCH PROJ

Duration of Study: 01 OCT 1996 TERM: 30 SEP 2001

Objectives: Evaluate alternative forage production systems for intensive cattle management

Approach: A system using kura clover (Trifolium ambiguum M.Bieb.) as a permanent ground cover and living mulch for sustainable corn production will be developed and tested. Four levels of kura clover suppression will be created by glyphosate application in early spring and corn will be sown with a no-till drill into the suppressed legume. Corn silage and grain yields and the ability of kura clover to meet total corn N needs will be determined. Recovery of kura clover by clonal growth from rhizomes the year after corn production will be measured. The agronomic performance of cup-plant (Silphium perfoliatum L.) as a long-lived, environmentally friendly, silage crop will be determined. Specifically, harvest management schedules and nutrient reuirements that will optimize persistence and forage yield and quality of this native prairie plant will be identified. Cup-plant's capacity to recycle nutrients in livestock will also be determined. The compatibility of several short and tall prairie grass species and domesticated forage and turf species in cup-plant production systems will be determined. Response variables to be measured include cup-plant yield, seasonal distribution of ground cover provided by the grasses, and rating of bird habitat potential

Progress: Six years of small-plot research have demonstrated that cup-plant has excellent agronomic potential in terms of yield, persistence, and laboratory measures of forage quality. We fed cup-plant silage to lactating dairy cows and discovered that we could feed 15% of the ration of dairy cows as cup-plant silage and not affect milk production. Milk production was depressed slightly but significantly when 30% of the ration was cup-plant. The silage contained significant amounts of butyrate, so the drop in milk production was likely do to poor fermentation of the silage. Although cup-plant silage contains more lactate than we have normally found in alfalfa or corn silages, the pH usually does not drop below 5.5. Our preliminary observations suggest that cup-plant has a high buffering capacity and it may be difficult to produce stable silage from this crop. Silage produced in 1998 had no detectable butyrate and will be fed in the next 2 months. Our earlier results demonstrated that cup-plant forage can accumulate substantial amounts of nitrogen and phosphorous. We have initiated a new experiment to test how much N and P the crop can remove and also how much of these nutrients it requires for production. After a two year experiment we concluded that kura clover can be used as a living mulch in corn without reduced corn silage or grain yields. The kura clover will recover to full production the following year. Our previous experiences demonstrated that if kura clover is not adequately suppressed, corn yields will be reduced. We initiated a new experiment in spring 1998 to determine the best management strategies to suppress spring growth of kura clover so that it does not interfere with corn establishment and early growth. Use of new herbicide resistant corn hybrids and their associated postemergence herbicides in this living mulch system allowed greater flexibility in control of kura clover competition.

We will continue evaluation of Liberty Link and Round-Up Ready hybrids in the kura clover living mulch system in 1999. Improved nitrogen-fixing inoculum strains for leguminous crops must be able to effectively competed for nodulation with indigenous strains, enhance legume productivity compared to that obtained with indigenous strains, and maintain stable expression of any added genes in the absence of selection pressure. A transposable element was constructed containing the tfx region, for expression of increased nodulation competitiveness, and the par locus for plasmid stability. The transposon was inserted into tetA f pHU52, a broad-host-range plasmid conferring the H2 uptake phenotype. The H2 uptake phenotype oxidizes the H2 and channels the resulting electrons through an electron transport chain that recovers most of the energy lost in H2 production in the form of ATP. The resulting plasmid, pHUTFXPAR, conferred the plasmid stability, trifolitoxin production, and H2 uptake phenotypes in the broad-host-range strain Sinorhizobium sp

Potential Implications: Because cup-plant tolerates very wet soil conditions, it could play a role in recycling agricultural nutrients from fertilizer and manure at the interface between conventional agricultural fields and wet-lands. The harvested and ensiled cup-plant, with nutrients that would have otherwise moved into wet-lands, would be fed to livestock. The kura clover living-mulch system for corn production continues to show promise as a means to reduce soil erosion and nitrogen fertilizer and herbicide inputs in corn production

Publications:

1. Zemenchik, R.A., K.A. Albrecht, C.M. Boerboom, J.G. Lauer, and R.M. Klemme. 1998. Agronomic, environmental, and economic implications of kura clover-corn intercropping. pp. 21-25, In American Forage and Grassland Council Proc., March 8-10, 1998, Indianapolis, IN

2. Albrecht, K.A., R.A. Zemenchik, and B.W. Kim. 1998. Kura clover: the persistent legume. pp. 50-52. In Proc. Wisconsin Forage Council, January 27&28, 1998, Eau Claire, WI

3. Albrecht, K.A., M. Rankin, and R.M. Sulc. 1998. PEAQ: A simple method to estimate alfalfa quality in the field. pp. 24-30. In Proc. Wisconsin Forage Council, January 27&28, 1998, Eau Claire, WI.

4. Albrecht, K.A. and B.W. Kim. 1998. Competition effects on kura clover rhizome development. Agronomy Abstracts. p. 107.

5. Woodfield, D., K.A. Albrecht, E.J Bures, and W. Green. 1998. Characterization and performance of Wisconsin white clover ecotypes. Proc. 15th Trifolium Conference. p. 15.

6. Albrecht, K.A. and B.W. Kim. 1998. Rhizome development of kura clover. Proc. 15th Trifolium Conference. p. 11

7. Albrecht, K.A. 1998. Kura clover-a promising legume for Wisconsin sheep pastures. Proc. 46th Spooner Sheep Day, p. 29

Investigators: Rusch, Donald

Institution or Affiliation: Wisconsin Cooperative Wildlife Research Unit, Madison, WI

Title of Study: The influence of cattle grazing on brown-headed cowbird parasitism rates: A determination of the parasitism-distance threshold

Funding Agency:

Duration of Study: 9/20/1995 to 8/31/1997

Objectives: In this study, we propose to address 3 separate research questions. First, we will continue to investigate the influence of grazing on songbird communities in Pinyon-juniper woodlands. We will use the BBIRD project methodology to survey bird abundance, nest success, and vegetation characteristics. Special emphasis will be placed on nesting success and the influence of nest site characteristics. Second, we will investigate cowbird movements and behavior. We will accomplish this using radio-telemetry to document movements associated with breeding, foraging, and roosting habitat. We will compare the use of Pinyon-juniper woodlands, ponderosa pine, and prairie grasslands. Behavioral traits of female cowbirds and the distance they move from grazing, with respect to rate of parasitism, are of special interest. Finally, we will test hypotheses regarding nest defense behavior of the western wood peewee and solitary vireo using taxidermic mounts of female cowbirds

Progress: (4/30/1999) Our research fulfills both an applied and basic research need. First, there is currently no other ongoing research that addresses the impacts of grazing on neotropical migrants in a widespread western habitat type such as Pinyon-juniper. Land managers face increasing amounts of scrutiny due to the federal lands grazing policies, but have little scientific data with which to make decisions pertaining to grazing impacts on biodiversity. Our research fills an applied need by developing management guidelines to mitigate the impacts of grazing on one aspect of biodiversity. Second, ecologists have long recognized the importance of larger herbivores in ecosystems, yet few attempts have been made to integrate their role in the ecosystem with that of other vertebrates. The intricate relationship of nest-parasite, host, and habitat poses a basic research mystery yet to be solved. Since 1992, we have documented avian communities in an ungrazed and grazed landscape, amassing a sample . . . exceeds 700 host nests. Our data base is unique; it will contribute basic biological information to better understand the complex interactions among vertebrates in the ecosystem. Work completed

Potential Implications: 1) Define the cowbird parasitism gradient at moderate distances from grazing. 2) Identify both the maximum threshold distance that cowbirds travel, and the minimum threshold distance where parasitism becomes compensatory. 3) Develop a model (logistic regression, kriging) to predict impacts of cowbirds on a primary host, the solitary vireo, at varying distances from grazing. 4) Identify grazing management strategies (spatial and temporal) that can be used to mitigate the impacts of parasitism on songbirds

Investigators: Undersander, Dan; Lyons, John; Bozek, Michael

Institution or Affiliation: Wisconsin Cooperative Fishery Research Unit, Stevens Point, WI

Title of Study: Using rotational grazing in riparian areas to control woody vegetation: Evaluating benefits to stream systems in Wisconsin

Funding Agency

Duration of Study: 7/1/1998 to 6/30/2000

Objectives: Stream ecosystems have been degraded by unrestricted livestock access across much of North America, including Wisconsin. Many farms in the Midwest rely on natural surface waters for watering livestock. Overgrazed riparian areas degrade water quality and fish habitat and decrease the quality and quantity of the fish population. Traditional Best Management Practices (BMPs) for farmers aimed at improving stream water quality and fishery resources have recommended that cattle be excluded from riparian areas in order to protect streamside vegetation and fish habitat. Cattle exclusion is often unpopular among Wisconsin farmers because it is expensive and takes land out of production. Nonetheless, fencing protects riparian areas by allowing vegetation to become more dense and full, which stabilizes streambanks. However, vegetation in fenced riparian areas changed rapidly from grasses to shrubs to trees and research southwestern Wisconsin suggests that stream habitat quality decreases as streambanks become wooded. If stream habitat and water quality decline as riparian areas become wooded, keeping riparian areas at some early stage of succession could benefit water quality and stream habitat. A new management practice that has been proposed to utilize riparian area forage and maintain good stream habitat and water quality is well-managed or intensive rotational grazing (IRG). Well-managed grazing allows farmers to utilize the production potential of riparian pastures while potentially protecting riparian vegetation and stream habitat quality. Determining how to best manage riparian areas so that forage can be utilized and aquatic habitats is a priority. While it is clear that unrestricted livestock access to streams is detrimental, it is not clear that fencing stock out and allowing conversion of these areas to woody vegetation is the best alternative. Habitat assessments and surveys of the biotic integrity of the fish community . . . be used to evaluate different riparian management strategies on cold and warmwater streams throughout southwestern and central Wisconsin. This project will help clarify the habitat and fish community differences resulting from maintenance of woody and grassy vegetation on streambanks and evaluate an alternative management practice to protect riparian areas and stream habitat and allow use by livestock.

Progress: (4/9/99) This project is currently in the project design phase

Investigator: P.A. Moore Jr., ; T.J. Sauer

Institution or Affiliation: AGRICULTURAL RESEARCH SERVICE

Title of Study: POULTRY WASTE MANAGEMENT

Funding Agency: USDA INHOUSE PROJ.

Duration of Study: 28 FEB 1997 TERM: 27 FEB 2002

Objectives: To 1) evaluate the effects of various manure management strategies on the environmental impacts to air, water, and soil resources; 2) study the factors that affect phosphorus chemistry and transport in soil, water, and manure; 3) evaluate the factors that influence surface water runoff within watersheds; 4) evaluate the ability to predict critical hydrologic areas within watersheds.

Approach: Research on the efficacy of alum treatment of poultry litter to reduce P runoff and inhibit ammonia volatilization will continue. Studies will be conducted on broiler litter, turkey litter, laying hen manure, liquid hog manure and cattle manure. Phosphorus runoff will be evaluated from grazed pastures fertilized with both alum treated and normal poultry litter. Other management practices, such as altering the amount of P in the diet of poultry and swine using phytase enzymes or low phytate corn, will also be conducted. Basic research on P transformations in soils and phosphate mineral solubility will also be conducted. Research on the factors affecting surface water runoff, such as soil properties, plant type, landscape position, slope, and grazing intensity will also be conducted. This information will be integrated into existing or new models to predict hydrologically active areas within watersheds.

Progress: Research was continued on the effects of treating poultry litter with aluminum sulfate (alum). The results from these studies indicate that treating litter with alum is a cost-effective best management practice that reduces the negative impacts of this important resource on the environment, while improving poultry production. Laboratory studies showed that alum could reduce ammonia loss from litter, even when applied at low rates. Results from small plot studies showed that normal poultry litter caused a buildup of soluble phosphorus in soils, while alum-treated litter did not, even at high rates. This research also showed that alum-treated litter did not cause an increase in aluminum runoff or uptake by plants. Although fescue yields were not significantly affected by fertilizer type, yields from plots fertilized with alum-treated litter were 7% higher than with normal litter. Results also showed that both normal and alum-treated litter caused an increase in soil pH, while ammonium nitrate caused a decrease in soil pH. In another small plot study, cattle manure was found to have little impact on phosphorus runoff from tall fescue plots, compared to poultry litter. In another small plot study, phosphorus runoff from manure from broilers fed diets containing either low phytic acid corn or phytase enzyme or a combination of the two was evaluated. Data from this study indicated that there were no significant differences in phosphorus runoff using these modified diets. A study on the effects of various native and improved pasture grasses on hydrology was also initiated. Data from this study indicated that tall fescue resulted in less runoff

than native species. Soils data were also collected from pastures which will be used for research on methods to predict hydrologically active areas in watersheds. In cooperation with USGS scientists, two springs draining a pasture watershed have been instrumented to measure water quality parameters. Water balance measurements on two research watersheds were initiated to compare potential nutrient movement in surface runoff to streams with transport via percolation to groundwater. A collaborative study with the National Soil Tilth Laboratory was conducted to monitor odor from an animal waste lagoon. Phosphorus runoff was monitored from watersheds which were fertilized with either alum-treated or normal poultry litter. Results showed that alum use resulted in 70% less phosphorus runoff than normal litter. Field trials on the efficacy of alum to improve poultry production were continued in conjunction with personnel from industry, universities, and various government agencies. These trials, which were conducted in 15 states and British Columbia, involved over 20 million birds. This research has resulted in one patent being issued and several patents pending. The rights to these patents have been licensed to General Chemical Corporation, who is marketing the product Al+Clear (poultry grade alum) to poultry producers throughout the United States.

Publications:

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2. Edwards, D.R., M.S. Coyne, T.C. Daniel, P.F. Vendrell, J.F. Murdoch, and P.A. Moore, Jr. 1997. Indicator bacteria concentrations of two Northwest Arkansas streams in relation to flow and season. Trans.

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9. Moore, P.A., Jr., T.C. Daniel, D.R. Edwards, and T.J. Sauer. 1997. Using aluminum sulfate to reduce ammonia emissions and ... litter. pp. 97-102 SE Sustainable Animal Waste Mgt. Proc. Univ. of Georgia

10. Moore, P.A., Jr., W.E. Huff, T.C. Daniel, D.R. Edwards, and T.J. Sauer. 1997. Effect of aluminum sulfate on ammonia fluxes from poultry ... broiler houses. Int. Livestock Envir. Symp. 2:883-891. ASAE, St.

Investigator: M.B. McBride; W.S. Reid, E. Harrison, S. Degloria, J. Duxbury, and T. Steenhuis

Institution or Affiliation: CORNELL UNIVERSITY

Title of Study: HEAVY METALS AND NEW YORK AGRICULTURE

Funding Agency: HATCH PROJ.

Duration of Study: 01 OCT 1997 TERM: 30 SEP 2002

Objectives: Characterize heavy metal inputs to agricultural soils in N.Y. from commercial fertilizers, animal manures and sewage sludges. Assess bioavailability of heavy metals in different source materials to selected crops on farms. Assess the impact of sludge-borne metals on groundwater quality. Develop spatial data bases of heavy metal content of N.Y. soils to assist decision making about land spreading of metal-contaminated wastes. Conduct detailed field-scale mapping of soil and crop metal contents on selected farms that have used sludges for some time.

Approach: Fertilizers and manures will be collected from various sources in N.Y. State, and analyzed for trace metals by ICP emission spectrometry. Analyses will also be conducted on surface soils and subsoils of representative farming regions of N.Y. in order to obtain baseline data. Greenhouse experiments will be conducted with undisturbed soil columns to assess the leaching potential of sludge-borne metals and the impacts of metals on sensitive forage crops. More detailed farm-scale analysis of trace metals in soils and crops will be conducted on farms where sewage sludge has been applied for substantial periods of time. These data will be used to develop balance sheets for metals in N.Y. farming systems, and to generate spatial data on metal distribution.

Progress: A number of sewage sludges, commercial fertilizers, liming products and dairy manures were analyzed by microwave HF acid digestion and inductively coupled plasma-mass spectrometry (ICP-MS) for 32 elements, including the important toxic trace metals. Generally, limestone materials, and nitrogen and potassium components of the fertilizers contained negligible concentrations of all the potentially toxic trace elements. The phosphate component, however, contained significant levels of cadmium, arsenic, uranium and vanadium. Manures had low concentrations of all potentially toxic trace elements and heavy metals , with the exception that total Zn and Cu averaged 187 and 134 mg/kg , respectively. Most manures had Cu less than 100 mg/kg, but one of the 20 manures had Cu above 1000 mg/kg. Further investigation revealed that this anomaly was probably due to manure contamination from the use of Cu salts in "hoof dips". Sewage sludges were found to be contaminated with numerous toxic trace elements, generally at much higher concentrations than those found in manures. Preliminary analysis of these survey results indicate little potential for long-term accumulation of most trace elements from conventional soil amendments, with the possible exception of Zn and Cu, which are added to feeds. The potential for soil contamination at the farm scale is much lower with conventional fertilizers than with sewage sludges.

Investigator: D.T. Hill, R.B. Muntifering, and W.C. Wood

Institution or Affiliation: AUBURN UNIVERSITY

Title: ANIMAL MANURE AND WASTE UTILIZATION, TREATMENT, AND NUISANCE AVOIDANCE FOR A SUSTAINABLE AGRICULTURE

Funding Agency: HATCH PROJ.

Duration of Study: 01 OCT 1996 TERM: 30 SEP 2001

Objectives: Develop management tools, strategies, and systems for land application of animalmanures that optimize productivity and are compatible with sustained land and water quality. Develop and evaluate constructed wetlands, riparian zones, and other vegetative systems for treating animal wastewaters. Develop physical, chemical, and biological treatment processes and engineering systems for management of manures and other wastes. Develop methodology, technology and mangement practices to reduce odors, gases, airborne mocroflora, particulate matter and other airborne emissions in animal production systems. Develop and evaluate feeding sysems for their potential to alter excretion of environmentally-sensitive nutrients by livestock.

Approach: Each participating scientist will b responsible for his specific objectives as in the past.

Progress: Work performed during 1997-98 involved the use of overland flow treatment of swine lagoon effluent in which a study was performed to determine the effects of loading rate on the chemical properties of a loamy sand soil. The results of the study show that the chemical properties of the soil were greatly modified with nitrate concentration in both the deep seepage (below the root zone of a pastureland grass) and runoff a great concern for the highest application rate (4 x typical fertilizer application rate, 2240 Kg N/ha-yr), The phosphate concentration was a concern in the runoff but not in the deep seepage. A study on constructed wetlands related plant fill ratio to water temperature in the cells. Un-vegetated control cells show greater variation of temperature year round when compared to either a 10% or 5% vegetated plant fill ratio. The 10% fill ratio cells had significantly higher temperature in the winter months that the 5% fill ratio. This data is useful in the design of constructed wetlands for nutrient removal since biological activity is directly related to temperature. Nitrogen (N) fluxes were studied in fescue pastures amended with broiler litter in Major Land Resource Areas of the Southeast (Coastal Plain (Alabama), Piedmont (Georgia), and Appalachian Plateau (Tennessee). Ammonia flux was generally less than 10 kg/ha, representing a loss of <6% of applied N. Denitrification flux ranged from -20 to 2500 g N2O-N/m2/hr, but was always <5% of applied N. Nitrogen budgets indicated a substantial surplus of N at all sites. Above- and below-ground N2O emissions resulting from swine waste applications were studied on three Alabama soils (Black Belt, Coastal Plain, and Appalachian Plateau). Greatest average N2O surface emission over a 16-d period was observed from Coastal Plain soil (466 mg N2O/ha/hr). However, greatest average N2O concentrations at depth were observed in Black Belt soil (6.9 L N2O/L soil air). The wastewater treatment efficiency of a two-tiered constructed wetland treating swine lagoon

effluent was evaluated at three wastewater loading rates for 29 months. The purpose of the study was to determine the maximum loading rate that the wetlands could operate and achieve the wetland effluent criteria of the USDA/NRCS. For the high, medium, and low loading rates, the hydraulic retention times were 5.1, 7.8, and 10.5 days, respectively, which achieved BOD5 loading rates of 11.5, 5.8 and 3.7 kg/ha/day. The respective TKN loading rates were 19.8, 10.0 and 6.0 kg/ha/day. Effluents from the low and medium loading rates met the UDSA/NRCS criteria of <30 mg/L for BOD5 and total suspended solids (TSS). The ammonia criterion for effluent from wetlands treating municipal sewage is <10 mg/L. The low loading rate achieved an effluent ammonia level of 10.7 mg/L. The study indicated that BOD5 and TSS effluent criteria (<30 mg/L) were met but the ammonia criterion (<10 mg/L) is more difficult to achieve. An alternative to discharging the wetland effluent is to treat the wastewater sufficiently to eliminate odor and enteric pathogens and then recycle the water to flush manure from the swine facilities.

Publications:

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2. Liu, F., C.C. Mitchell, J.W. Odom, D.T. Hill, and E.W. Rochester. 1998. Swine lagoon effluent disposal by overland flow: I. Effects on forage production and uptake of N and P. Agronomy Journal. 89:900-904.

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5. Payton, J.D. and D.T. Hill. 1998. Plant Fill Ratio Effects on Water Temperature in Constructed Wetlands for Poultry Lagoon Wastewater Treatment. ASAE Paper No. 98- 4118. ASAE. St. Joseph, MI 49085.

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10. Sullivan, D.G., C.W. Wood, M.L. Norfleet, and W.F. Owsley. 1998. Ammonia volatilization

losses from a swine waste amended system. p. 334. In: Agronomy Abstracts, ASA, Madison, WI.
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15. Marshall, S.B., C.W. Wood, M.L. Cabrera, E.A. Guertal, and M.D. Mullen. 1998. Non-gaseous pathways for nitrogen flux following amendment of fescue pastures with broiler litter. p. 7. In: Southern Branch Agronomy Abstracts, ASA, Madison, WI.

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18. McCaskey T.A. and N.K. Gurung. 1998. Constructed wetlands for animal manure treatment and odor control. 1998. Proceedings, National Poultry Waste Management Symposium. Springdale, AR. October 19-21. pp.359-367.

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Investigator: T.C. Daniel

Institution or Affiliation: UNIVERSITY OF ARKANSAS

Title of Study: IDENTIFICATION OF THRESHOLD SOIL TEST PHOSPHORUS LEVELS TO MINIMIZE EUTROPHICATION

Funding Agency: HATCH PROJ.

Duration of Study: 01 NOV 1996 TERM: 30 SEP 2001

Objectives: The overall objective of the research is to develop a method for identifying threshold soil test phosphorus levels above which no additional phosphorus should be added either from the application of manure or commercial fertilizer. This requires accomplishment of several subobjectives, including the development of a portable small-scale rainfall simulator and a method to determine the relationship between the amount of phosphorus added and the corresponding elevation in soil test phosphorus.

Approach: A small (1 m2) portable rainfall simulator will be constructed by integrating the use of more water efficient nozzles in combination with solenoids to produce uniform rainfall patterns. Given boundary conditions such as a 5 cm hr-1 storm and an upper level of 1 mg l-1 of runoff phosphorus, cut-off levels of P will be identified by using data collected from the simulation runs in combination with soild test P values. The investigators will begin with a pilot project between Arkansas, Pennsylvania, and Texas. Values from the small simulator will be compared with those from the larger simulator conducted on soil varying in known levels of soil test P. Once perfected, the project will be expanded to other states, such as North Carolina, attempting to identify threshold levels of soil P.

Progress: Soils that contain high P levels can become a primary source of dissolved reactive P (DRP) in surface runoff, and thus contribute to accelerated eutrophication of streams and lakes. We compared results from several soil test P (STP) methods on a single soil and found they all gave results significantly correlated to DRP levels in runoff, but distilled H2O and NH4-oxalate methods gave the best correlations. We hypothesized that results might differ on other soils, so runoff studies were conducted on three Ultisols to determine which STP method accounts for DRP levels in runoff across soil series, and what effect site hydrology has on the correlation between STP and runoff DRP concentrations. Surface soil (0-2 cm depth) of pasture plots (7 percent slope) was analyzed by Mehlich III, Olsen, Morgan, Bray-Kurtz P1, NH4-oxalate, and distilled H2O methods. P saturation of each soil was also determined by three different methods. Simulated rain was applied at 75 mm h-1 to produce 30 min of runoff from each plot. All correlations of STP to runoff DRP were significant ($p<0.01$) regardless of soil series or STP method used, with most STP methods giving high correlations ($r>0.90$) on all three soils. For a given level of H2O-extractable STP, low runoff volumes coincided with low DRP concentrations. Therefore, when each DRP concentration was normalized for (divided by) the volume of plot runoff, correlations to H2O-extractable STP had the same ($p<0.05$) regression line for each soil. This identifies the importance of site hydrology in determining P loss in runoff, and may provide a means of developing a single relationship for a

range of soil series. We conducted an experiment to investigate the hypothesis that seasonal changes in field conditions (especially soil moisture) and the practice of air drying soil samples prior to analysis may affect such correlations. Grass plots with a wide range of STP were randomly divided into two groups. In May (wet season), soil samples were taken from each plot in the first group, simulated rain was applied (75 mm h-1) to produce 30 min of runoff, and filtered runoff samples were analyzed for DRP. Each soil sample was analyzed for H2O content, sieved (2 mm), and split into two subsamples. One subsample from each plot was kept field-moist, and the other was air dried. Phosphorus saturation was determined only on air-dry soil, but all soil subsamples were analyzed by Mehlich III and distilled H2O methods. In August (dry season), the second group of plots received the same treatment. All correlations of STP to runoff DRP were significant ($p<0.01$), regardless of season or STP method. Water-extractable STP from air-dry soil (mean = 28.5 mg kg-1) and Mehlich III STP (mean = 145 mg kg-1) were not affected by season, but DRP concentration in August runoff (mean = 1.05 mg L-1) was almost double that in May (mean = 0.57 mg L-1), so the resulting correlations were affected. Water-extractable STP from field-moist soil was higher in August (mean = 23 mg kg-1) than May (mean = 16mg kg-1), and P saturation levels showed a similar trend. Runoff volumes were smaller in August, so season had little effect on mean DRP mass loss.

Publications:

1. Daniel, T.C., A.N. Sharpley, and J.L. Lemunyon. 1998. Agricultural phosphorus and eutrophication: A symposium overview. J. Environ. Qual. 27:251-257.

2. Lemunyon, J. and T.C. Daniel. 1998. Phosphorus management for water quality protection: A national effort. p. 1-4. In J.T. Sims (ed) Soil test phosphorus: Environmental uses and implications. USDA-CREES Regional SERA17 Committee bulletin No. 389.

Investigators: Collins Jr., E. R

Institution or Affiliation: VIRGINIA POLYTECHNIC INSTITUTE

Title of Study: BEST MANAGEMENT PRACTICES FOR REDUCING POLLUTION FROM CONCENTRATED LIVESTOCK OPERATIONS

Funding Agency: HATCH PROJ

Duration of Study: 01 OCT 1997 TERM: 30 SEP 2001

Objectives: 1. Determine effectiveness of Dairy Loafing Lot Rotational Management System in reducing N, P, bacterial yield, and sediment loss. 2. Provide a measure of water quality improvement afforded by installation of alternative off-stream watering systems. 3. Provide a measure of water quality improvements afforded by installation of cattle travel lanes and improved stream crossings

Approach: Field studies on cooperating commercial farms to evaluate effectiveness of the three BMPs addressed in "Objectives". Objective 1 will be evaluated by comparing pre- and post-BMP runoff using automated and grab sampling, and using portable rainfall simulator to assure measurable cause and effect precipitation events. Objectives 2 and 3 will be evaluated using automated and grab sampling, as well as subjective observation of cattle grazing and watering practices

Progress: Work on nitrogen, phosphorus, and sediment loss from dairy loafing lots as affected by rotational vegetated paddocks included study sites on commercial dairy farms in two physiographically different regions of Virginia. Based on precipitation events generated by a rainfall simulator, it was concluded that total suspended solids (TSS), nitrate (NO sub 3), ammonia (NH sub 4), phosphate (PO sub 4), and total filterable phosphorus loadings from the grassed loafing paddocks Best Management Practice were reduced as compared to the bare "sacrifice" lot. Runoff was also reduced from the grassed loafing paddocks, allowing greater opportunity for rainfall infiltration and trapping of nutrients and other pollutants. Reduction in bacteria losses from study areas was inconclusive. Work on alternative water systems and watershed model for NPS assessment and demonstration was completed on three cooperator cattle farms in Franklin County, VA. Due to the lack of site condition controls and different weather conditions over the two-year study, statistically-based conclusions were not possible. However, distinct trends were observed that showed improvements in stream water quality after the off-stream watering systems were installed. Many dairymen are adopting the Dairy Loafing Lot Rotational Management System for improving cattle husbandry, and water quality on their farms. Demonstrations and local meetings have made growers and others aware of the advantages of the off-stream watering practice, and its possible impact on improving water quality

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Investigators: James F. Ruhl

Institution or Affiliation: U.S. Geological Survey

Title of Study: Quantity and Quality of Seepage from Two Earthen Basins Used to Store Livestock Waste in Southern Minnesota During First Year of Operation, 1996-97

Funding Agency: U.S. Geological Survey and Minnesota Pollution Control Agency

Duration of Study: 1996-1997

Objectives: Evaluate potential impacts of seepage from two representative earthen basins used to store livestock waste in Minnesota on local ground water.

Approach: Seepage monitoring systems were installed at two earthen basins. The systems were designed to measure the quantity of seepage from the sidewalls and bottoms of the basins. The systems also were designed for collection of seepage samples from the sidewalls and bottoms of the basins. The samples were chemically analyzed to determine concentrations of nitrogen compounds, chloride, and Fecal coliform bacteria.

Progress: Data-collection phase of the study completed. Report preparation near completion.

Publications: A U.S. Geological Survey Water Resources Investigations Report is expected to be published during the latter part of 1999 or the early part of 2000.

Investigators: Kent D. Becher, Kimberlee K.B. Akers

Institution or Affiliation: U.S. Geological Survey- Water Resources Division

Title of Study: Comparison of Water-Quality in Four Small Watersheds Containing Animal Feeding Operations in Iowa 1996-98.

Funding Agency: U.S.G.S.- National Water Quality Assessment Program (NAWQA)

Duration of Study: March 1996- September 1998

Objectives: To determine if there are differences in water-quality in small watersheds where there are different densities of animal feeding operations.

Approach: Water-quality data that were collected as part of the NAWQA were used to compare four different watersheds. GIS was used to delineate the drainage basins, locations of AFO's, and to determine manure inputs into each basin. Concentrations and yields of nutrients were compared between sites using a Wilcoxon Rank sums test.

Progress: Initial comparisons between sites indicate that there may be some relationships between AFO densities and water quality. Ancillary data sets (soil types, slope, organic carbon contents, etc.) are currently being used to determine if there are other factors for these statistical differences. The poster that will be presented at the AFO conference in Fort Collins, Colorado will present the results.

Publications: Currently, no publications on this issue are planned. However, there are several NAWQA reports that will include data from areas of Iowa with high densities of AFO's. Most of these reports are being prepared this year and should be published in 2000.

Investigators: Dana Kolpin (USGS), David Riley (U of I), Mike Meyer (USGS), Peter Weyer (U of I), and Mike Thurman (USGS)

Institution or Affiliation: U.S Geological Survey, University of Iowa – Center for Health Effects of Environmental Contamination

Title of Study: Occurrence of antibiotics in Iowa streams

Funding Agency: USGS, University of Iowa

Duration of Study: 1999

Objectives: Determine if antibiotics used for livestock production and human health are present in streams across Iowa

Approach: A network of 30 streams were selected across Iowa representing basins containing low to intense hog production. Samples collected during the first runoff even following snowmelt (a time when there is an increased likelihood of antibiotic transport to streams). Samples will be analyzed for a set of 20-30 antibiotics using reporting limits estimated to be between 0.05 to 0.2 ppb.

Progress: All water samples have been collected for this study. Awaiting analytical results from the laboratory

Publications: None to date

Other Comments: This is an initial reconnaissance project. More research may follow.