COSTS AND EFFECTS of the 1989 WINTER EMERGENCY DEER FEEDING PROJECT

A Report to

The Minnesota State Legislature

by the

Section of Wildlife

Division of Fish & Wildlife

Department of Natural Resources

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EXECUTIVE SUMMARY

In response to severe winter conditions over most of northern Minnesota during the winter of 1988-89, the Department of Natural Resources (DNR) initiated a large-scale emergency deer feeding program. A study of the costs of the program, the effects of the feeding on deer populations, and a comparison of Minnesota's deer feeding policies with other state's policies was required as part of the legislation that provided funding for the 1989 program. The large scale of the 1989 feeding program provided an excellent opportunity to document the costs and impacts of an extensive feeding effort for use in developing future deer feeding policies and programs.

A total of 3,955 tons of pelleted feed was purchased and distributed by the DNR in a 46,000 square mile area of northern Minnesota in 1989. The program cost the Department $1,071,492 and required more than 17,000 hours of staff time to implement. In addition, an estimated 8,000 volunteers contributed more than 230,000 hours to the feeding effort.

The analysis shows that a maximum of 54,038 deer in forest Deer Management Units (DMUs) (9.3% of the deer population), and 18,294 deer in farmland DMUs (22.3% of the population) were reached by the feeding program. The proportion of deer fed ranged from 4.4% in the Rainy River DMU in the north-central part of the state to 59.4% in the northern portion of the Prairie DMU in west-central Minnesota.

In spite of the magnitude of the feeding effort in 1989, deer populations in both forest and farmland DMUs declined due to the severe winter conditions as a result of increased mortality of fawns and reduced production of fawns the following spring. However, the feeding program was able to moderate the impact of the weather on the following fall's population. The analysis shows that in forest DMUs there were an additional 16,196 deer available in the fall of 1989 due to the feeding program, or 3.1% more deer than would have been available if no feeding had taken place. In farmland DMUs where deer were more accessible and a higher proportion of the population was reached by the program, the increase in the fall, 1989 population was 4,703 deer, 7.2% more than if no feeding had taken place.

The cost per deer fed was very similar between DMUs and averaged $14.69, or $.235 per deer per day. The cost for each additional deer added to the following fall's population was also relatively consistent between DMUs and averaged $51.27. Feeding efficiency was calculated as the cost to raise the following fall's deer population (on a square mile basis) by 10%. Because the proportion of deer fed was much higher in the farmland than in the forest, feeding efficiency was more than three times greater in the farmland DMUs ($26.20) than in the forest ($81.50).

Based on this analysis, the following conclusions are made concerning emergency winter deer feeding in the northern part of the state:

1) The response by DNR staff and volunteers during the 1989 emergency probably represents the maximum effort possible. In most cases, the number of deer reached by future feeding programs in the DMUs involved in this analysis would be similar to 1989.

2) Without volunteer help,an extensive emergency deer feeding program would be impossible to implement.

3) Deer feeding is very expensive and diverts work from important long-term management activities. Also, the effectiveness of feeding is highly variable between DMUs. Consequently, state-funded feeding programs should only be considered in those winters and in those parts of the state where it is most effective and necessary.

4) Deer feeding policies of surrounding states and provinces oppose emergency deer feeding programs except in some farmland areas.

5) The effectiveness of feeding is primarily a function of the proportion of deer reached in DMU-sized areas or larger.

6) Improved year-around deer habitat can moderate the impact of a severe winter on deer populations and can reduce the need for emergency deer feeding. Department efforts to improve deer habitat have been given a higher priority in forest DMUs, than in the farmland.

7) While the cost per deer fed is similar in forest and farmland DMUs, the cost to increase the following fall's deer population by 10% is more than three-times higher in the forest than in the farmland.

8) In spite of the large scale of the 1989 feeding program, deer populations declined due to the winter weather, even in those areas where a high proportion of deer were fed. In addition, the deer population rebounded very quickly in most areas the year following the feeding program.

9) Emergency feeding of deer is feasible in the Agassiz, Red River, and northern portion of the Prairie DMUs, and is probably feasible in the Big Woods DMU. Deer in these farmland DMUs are dependent on agricultural crops for food; have relatively poor winter cover available; and occur at much lower densities than forest deer. Feeding may be justified when deep and/or crusted snow and extensive crop harvests limit food availability. This analysis has shown that a high proportion of deer can be reached by a feeding program in these agricultural areas and benefits to deer populations over broad geographic areas can be demonstrated.

10) Emergency feeding of deer is not feasible and justified in the Rainy River, Itasca, and Mille Lacs DMUs. This is due to the low proportion of deer that can be reached in these forest units by a feeding program, and the ability of forest deer populations to withstand severe winters better than farmland populations.

11) Emergency feeding of deer in the Superior DMU may be feasible because deer are more concentrated than in other forest DMUs and a higher proportion of deer can be reached. However, deer feeding may act to artificially maintain deer populations in this unit.

12) Where state-funded feeding programs are not warranted, private feeding efforts can benefit small, localized deer populations.

It is recommended that future state-funded deer feeding programs in the northern part of the state be restricted to farmland DMUs, and only when the Department determines that weather and/or food conditions warrant such actions. Future feeding programs should rely on volunteers for distribution of feed to deer, and should be initiated as late as possible to reduce costs of the program while still providing benefits to deer populations. Feeding programs should be designed to supplement, rather than replace, private feeding efforts for maximum benefits to the deer population. During severe winters where state-funded feeding programs are not warranted, the DNR should assist private individuals wishing to feed by providing information on the location of deer concentrations, and how, what, and when to feed.

It is also recommended that monitoring of deer conditions and deer populations during winter be intensified. Research is necessary to develop new techniques and strategies to assess the effect of winter weather on deer. Efforts to protect and improve summer and winter deer habitat should be expanded to mitigate the effects of weather on deer survival and production, and to reduce the need for future deer feeding programs. Research to assess the impact of deer habitat improvements on deer survival during severe winters should also be undertaken. At the same time, deer populations should continue to be managed at appropriate levels to minimize damage to agricultural crops and natural food and cover, and to allow deer populations to recover quickly from future severe winters.

There is a great need to educate the general public and policy makers on deer feeding issues, and deer biology and management. Much of the controversy that has surrounded the deer feeding issue has resulted from either a lack of information or misinformation regarding costs and effects of feeding. This report provides much of the information necessary for the Department, the legislature, and the public to make informed decisions on whether state funds should be used for future feeding programs.

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INTRODUCTION

The Laws of 1989, Chapter 335, Article 1, Section 21, Subdivision 7, require the Commissioner to "study the costs associated with emergency deer feeding and the effect that the feeding project has on the deer population. The study shall be completed by January 1, 1991, and include a comparision of Minnesota's emergency deer feeding program to emergency deer feeding programs in other states."

The debate over feeding has gone on for decades due to the emotional nature of the issue, the economic and recreational value of Minnesota's deer herd, the cost to feed deer, and questions regarding the impact of feeding on deer populations. Unfortunately no state, including those that have taken strong positions against feeding, has offered a substantive evaluation of the feeding issue.

The controversy was intensified in the 1970's by the development of a pelletized deer feed that satisfied a deer's nutritional requirements. Despite the availability of a suitable feed, the issue of whether it is biologically or economically feasible to feed enough deer to have a significant effect on the deer population was still unresolved.

The 1989 deer feeding effort in Minnesota provided an excellent opportunity to document the costs of an extensive deer feeding program in the northern part of the state, and to assess the impact of the feeding effort on deer populations. This analysis will provide information that can be used to develop future deer feeding policies and programs.

HISTORY OF DEER FEEDING IN MINNESOTA: During the winter of 1968-69 the Department and many volunteers engaged in an extensive browse cutting project to help deer survive severe conditions throughout the northern part of the state. The northern deer herd, already at low densities due to overharvest of does, deteriorating habitat and several severe winters, was devastated by that winter. In response, legislation that allowed the Department to restrict the harvest of antlerless deer was approved. Perhaps equally important, the need for improved deer habitat was recognized and the Deer Habitat Improvement Program was authorized and funded in 1969.

January 1975 brought what was termed "the storm of the century". Some emergency feeding of corn was done in the farmland but snow conditions in the forest did not warrant emergency feeding.

Severe conditions early in the winter of 1977-78 in the northwest part of the state resulted in an emergency request for $100,000 from the Game and Fish contingency fund to purchase feed pellets and distribute to deer in that area. In other parts of the state deer did well under average winter conditions.

The winter of 1981-82 was severe and triggered calls for an emergency deer feeding effort. The sum of $250,000 was appropriated from the Game and Fish Fund for that purpose. Region 1 (Bemidji) distributed 137 tons of pelletized feed; Region 2 (Grand Rapids) sent out 195 tons; and Region 3 (Brainerd) put out 115 tons.

Severe conditions arrived early in 1983-84, especially in the southern part of the state. Large quantities of surplus corn were provided for pheasants and deer in the farmland. The only areas in northern Minnesota where any feeding was done were along the North Shore and near Isabella and Ely. The feeding program started during the first week of March and used 50 tons of pellets by the end of winter.

Winter severity indices were high across northern Minnesota in 1985-86; however, spring arrived early and deer feeding was limited to early March at a few sites. International Falls received a total of 28 tons of pellets; Isabella received 12 tons; and 10 tons each went to Brainerd and the Mille Lacs Wildlife Management Area.

The next severe winter, 1988-89, is the subject of this report.

DNR DEER FEEDING POLICY: There have been a number of unsuccessful attempts to develop a Department policy on winter deer feeding. A policy has not been approved for several reasons. A significant problem has been that most people who feed deer as a hobby view deer feeding on the basis of individual deer "saved". Wildlife managers, however, consider deer feeding in the context of its effects on the local or regional deer population.

Another complication with the deer feeding issue has been the difference between the farmland and the forested regions, particularly with regard to access to deer in wintering areas. Unfortunately, the public often demands that once feeding starts, it should occur everywhere. In widespread winter emergencies, the Department has had difficulty establishing any limitations for the feeding effort and has been forced to feed in areas or at times when the Department felt it was not feasible or justified.

POLICIES OF OTHER STATES/PROVINCES: The following are summaries of positions and/or policies regarding deer feeding that were received from surrounding states and provinces.

Wisconsin - The Wisconsin Bureau of Wildlife Management has concluded that emergency winter feeding will not have a measurable effect on unit sized deer populations because logistics and costs will not permit total care of all deer. However, they recognize that the public will probably continue to expect the Department to take actions during severe winters. As a result, the Bureau has recommended a policy be adopted for winter deer in the northern forest that includes the following provisions:

(1) The department will seek appropriate deer harvest quotas to maintain deer populations at established goals.

(2) Habitat management will emphasize maintaining summer range quality which will produce well nourished deer in the fall and enhance their overwinter survival.

(3) The department will monitor wintering deer herds by surveying yarding areas and measuring winter severity.

(4) The department will implement existing deer yard plans to maximize browse and perpetuate priority cover.

(5) The department will provide technical advice and guidance to individuals and groups on where, when, what and how to feed privately acquired food to deer during severe winter.

Michigan - The Michigan Department of Natural Resources is opposed to using game and fish protection fund monies to support deer feeding programs. The efforts and money available should be spent to increase the natural food supply through carefully planned commercial timber harvests and in land acquisition programs designed to provide public land for deer hunting.

Michigan's policy states that:

1. The cost of a large-scale feeding program far exceeds the value or advantages that might be gained.

2. Artificial feeding will cause serious range deterioration in the areas where deer are fed, causing a drastic decline in the "natural" carrying capacity of the range.

3. The deer fed successfully one winter will be present to reproduce and compound the food-shortage problem the next winter. If feeding is carried out year after year, without an adequate deer harvest, the costs of a feeding program large enough to handle the extra deer will "snowball".

Michigan's policy does not discourage well-devised artificial feeding programs sponsored and paid for by private individuals and groups because of the recreation such programs can provide, but artificial feeding is not a low-cost long-term solution to a winter-food-shortage problem on public lands.

Ontario - This province provided a report entitled Deer Biology and Management in Eastern Region that includes a comprehensive evaluation of the dietary aspects of winter feeding of deer but does not consider costs and benefits of feeding operations. Ontario did not submit any provincial management policies in response to our request.

Iowa - Iowa has not embarked on any winter feeding programs in the last 20 years and has never developed a formal deer feeding policy, strategy or guidelines. They do provide food plots (mainly corn) on public wildlife areas as part of their general deer management program. These food plots are often heavily utilized during the severe winters.

North Dakota - Winter deer feeding at Game and Fish Department expense is primarily a program to alleviate deer depredation upon stored crops. Severe winters increase this problem. North Dakota's feeding policy is contained in their depredation report which states that emergency deer feeding programs are a last resort measure to protect farmer-rancher livestock feed supplies from severe deer depredation and/or to feed deer that would otherwise starve to death or become so weakened that they would have little chance of producing fawns the following spring.

Their feeding program consists of providing the participant (farmer-rancher-cooperator, local game warden, sportsmen, etc.) with an adequate supply of oats and barley to assure at least the weekly protection of livestock feed supplies and/or the weekly well being of the deer involved in the problem area. The specific time period for which oats and barley will be supplied will be determined by the Land Manager using weather factors, time of the winter period, severity of problems, etc.

South Dakota - Correspondence from South Dakota states that the only winter feeding they do is almost exclusively to alleviate depredation on stored livestock food, and not to address deer starvation.

Manitoba - As in North and South Dakota, Manitoba's policies are to save natural habitat and prevent deer depredation upon stored crops. Manitoba's deer range is primarily in the southwestern corner of the province and 85 percent of that is in private ownership. Emergency funding requires a special appropriation of General Revenue which must be balanced against other Provincial needs such as hospital beds, etc. Manitoba managers feel that provision is a good safety valve. Government funds pay only for feed, not transportation or labor.

A Summary of Deer Feeding Policies of Other States/Provinces

State/Province	Policy and/or Action
Wisconsin	- DNR advice only, private purchase of food recommended
Michigan	- Opposed to large scale feeding, private feeding acceptable
Ontario	- Research on dietary aspects, working on policy
Iowa	- No policy and no feeding organized or sponsored by DNR
North Dakota	- Feeding deer last resort to protect livestock feed
South Dakota	- Any feeding done is only to alleviate depredation
Manitoba	- Feed to alleviate depredation and maintain deer in agricultural area

THE PROBLEM OF WINTER WEATHER

Winter weather severity and habitat are the key factors affecting winter deer survival and fawn production in both farmland and forest areas in the northern half of Minnesota. Habitat plays a primary role in determining the carrying capacity of an area. Carrying capacity is the maximum number of deer that an area can support without depleting food resources. However, adverse winter conditions such as deep snow, low temperatures, and wind can result in winter deer losses even when populations are below carrying capacity and have adequate food resources. Karns (1980) characterized the situation well when he stated "... in the northern environment there are winters that extend beyond the deer's physiological limits, either in total length -- or snow depth, (and) result in (above normal) mortality. This is not a function of deer population density... but is a basic physiological property of white-tailed deer. The deer are unable, under certain conditions, to meet their nutrient needs and die...". Severe winter weather may also increase predation rates and may affect the production and survival of fawns born the following spring.

Currently, most of the northern forest habitat provides enough food and cover to maintain deer populations at spring densities of 10 to 20 deer per square mile. In farmland areas, the amount of natural food and cover is much more limited and this, combined with the potential for excessive deer damage to agricultural crops, requires that the DNR manage deer populations at much lower levels than in the forest. Spring population densities in the northern farmland generally range from 1 to 9 deer/mi ^{2}.

In forested areas, some winter deer mortality is expected, even in mild winters. One study in the north-central part of the state found that during a normal winter, 5.5% of the adults and 11% of the fawns died (Fuller, 1990). This same study found that in winters with an average weekly snow depth of 14 to 17 inches, fawn mortality increased to 40%, but adult mortality remained low. There is not as much research available for farmland deer. However, because of their use of agricultural crops for food, farmland deer generally enter the winter in much better condition than forest deer and as a result, fewer deer die during most winters. However, during severe winters when access to agricultural crops is limited due to early crop harvests or deep or crusted snow, the potential for very significant deer losses is higher than in the forest. This is due to the lack of natural deer foods in northern farmland areas, and relatively poor cover to insulate deer from the effects of temperature and wind. As an example, wildlife managers in a 21 county area of northwestern Minnesota estimated that from 5% to 30% of the total deer herd in their work areas (primarily fawns) was lost during the severe winter of 1977-78 (Gunvalson and Ordahl, 1978).

Fluctuations in winter mortality directly influence the number and distribution of antlerless permits offered. After a severe winter, limited numbers of permits are issued, resulting in a reduced harvest of does and fawns which, in turn, will allow the herd to rebuild to goal levels.

Emergency feeding of deer in late winter can reduce deer winter mortality by slowing the depletion of energy reserves and allowing some winter-stressed deer who would die without access to emergency feed (mostly that year's fawns), to survive until spring. Emergency feeding may also result in healthier fawns born the following spring which will lead to higher survival rates for these fawns. In addition, emergency feeding in the farmland can maintain female fawns in good enough condition to carry fawns to term that would otherwise have been lost.

It is important to recognize that, as this analysis will show, not all deer are benefitted equally by emergency feeding. Many deer that were fed would have survived the winter and/or produced healthy fawns even if no feeding took place. The quality of deer habitat, especially in forest areas, has improved significantly in the past 10 years. Increased timber harvest levels have resulted in abundant summer and winter deer browse. In addition, Minnesota's Deer Habitat Improvement Program (DHIP) has spent close to $1,000,000 each year to improve summer and winter deer habitat (food and cover) in both farmland and forest areas so that more deer will enter the winter in better condition and be able to survive the rigors of winter weather. The winter of 1988-89 did not produce unexpected conditions and the DHIP program and other habitat improvement efforts were designed to reduce the influence of such a winter.

WINTER WEATHER - 1988-89

In 1988, drought throughout most of the state resulted in poor agricultural crops and an early crop harvest. However, a mild fall and a late growth of vegetation that was spurred by ample rain in the northern part of the state during September allowed deer to enter the winter in relatively good condition. Mild temperatures continued through November and early December. Late December, however, brought a drastic change.

SNOW DEPTHS: Snow reached depths of 18 inches across much of the northern deer range between Christmas and New Year's Day (Figure 1). Snow on the ground at 9 stations was more than 18 inches until late March when warm weather reduced depths at Agassiz, Aitkin, Grand Marais, Karlstad and International Falls to less than 18 inches. By April 3 deer sinking depth (the depth below the snow surface an average deer will sink) was only 5 inches, despite snow depths over 18 inches. Reports for April 10 show all stations, except Isabella, had less than 18 inches of snow.

TEMPERATURES: By January 8, stations in northern Minnesota reported from 9 to 23 days with sub-zero readings. A slight warming occured in late January, which was followed by extreme cold until late March when unseasonably warm temperatures began to improve conditions for deer.

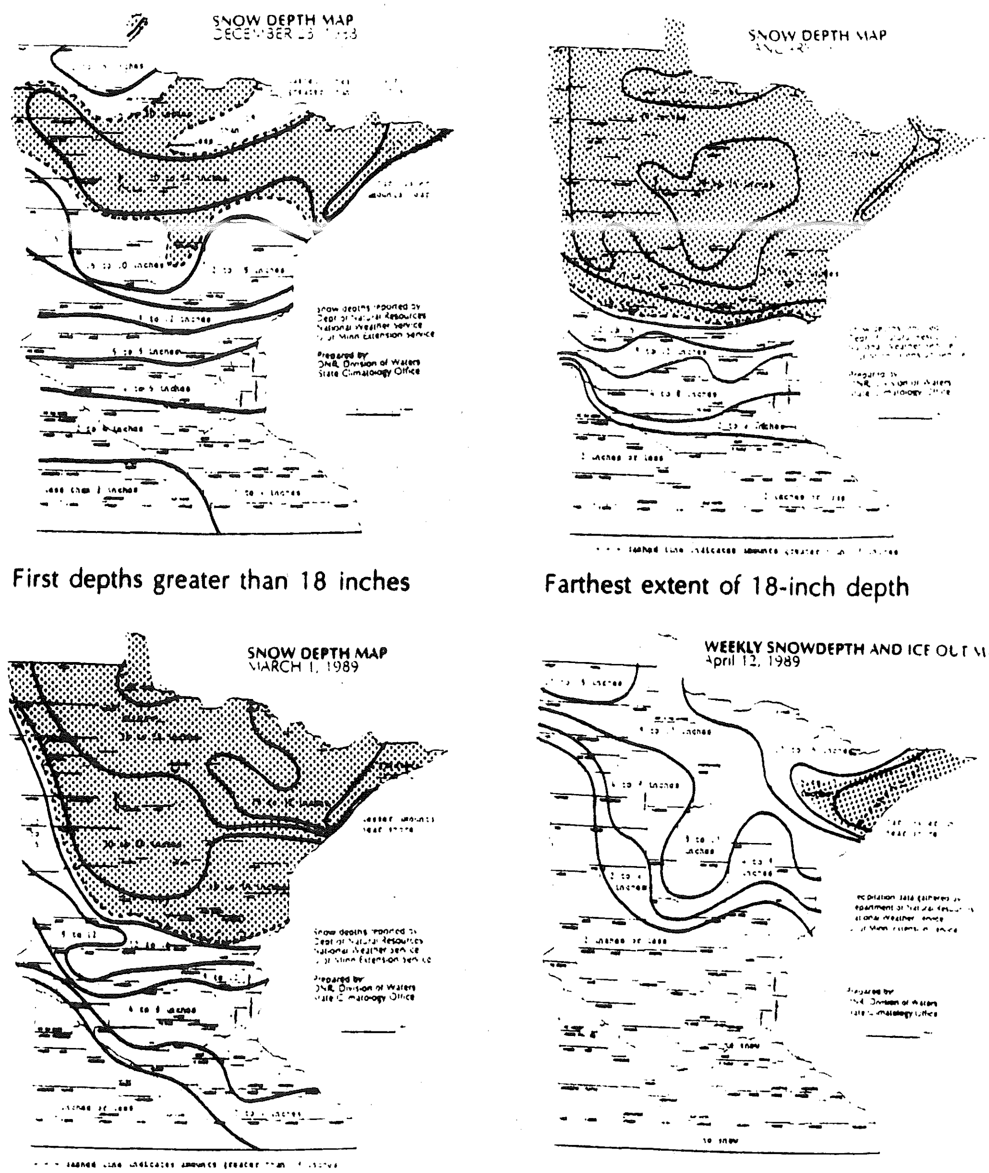
WINTER SEVERITY INDEX: Several methods have been used to assess the effect of winter weather upon deer. In the 1930's, biologists observed that 12-13 weeks with at least 18 inches of snow on the ground caused deer starvation. Research in subsequent years suggested that assessments of winter severity must also incorporate some measure of snow compaction and temperature. Travel and access to food can be enhanced when snow compaction or a strong crust keeps deer from sinking through snow. Low temperatures drain the physical condition of deer by forcing them to burn energy to stay warm.

Verme (1968) developed a system for evaluating winter severity by measuring snow depth, deer sinking depth, (by penetrometer), and heat loss (by a katathermometer) to determine a Winter Severity Index (WSI). Wildlife managers in northern Minnesota carried out these types of WSI measurements from 1967 to 1988. However, beginning with the winter of 1988-89 the simpler "Wisconsin" method of determining a WSI has been used. The Wisconsin method evaluates only the sum of days with a minimum temperature of 0 degrees F. or below and the number of days with more than 18" of snow on the ground.

Winter severity indices have been useful in assessing the impact of a winter upon deer. Indices for the winter of 1988-89 indicate that it was among the most severe Minnesota has experienced in recent years (Figure 2). Generally, a WSI of less than 50 indicates a mild winter, 51 to 80 a moderate winter, 81 to 100 a moderately severe winter, and over 100 a severe winter.

Based on the winter severity index measured at 9 stations in northern Minnesota, the winter of 1988-89 was severe (Table 1).

Snow Depths by Time



First depths greater than 18 inches

Farthest extent of 18-inch depth

Depths when feeding began

Last depths greater than 18 inches

Figure 1. Snow depths by time, 1988-89. Shaded areas indicate snow depths greater than 18 inches.

DEER MOBILITY: From January 10 to April 7, 1989, 52 deer wintering evaluation reports were submitted to the central office by field personnel. These reports reveal much about the status of deer that is not apparent from WSI readings alone and covered nine counties across northern Minnesota.

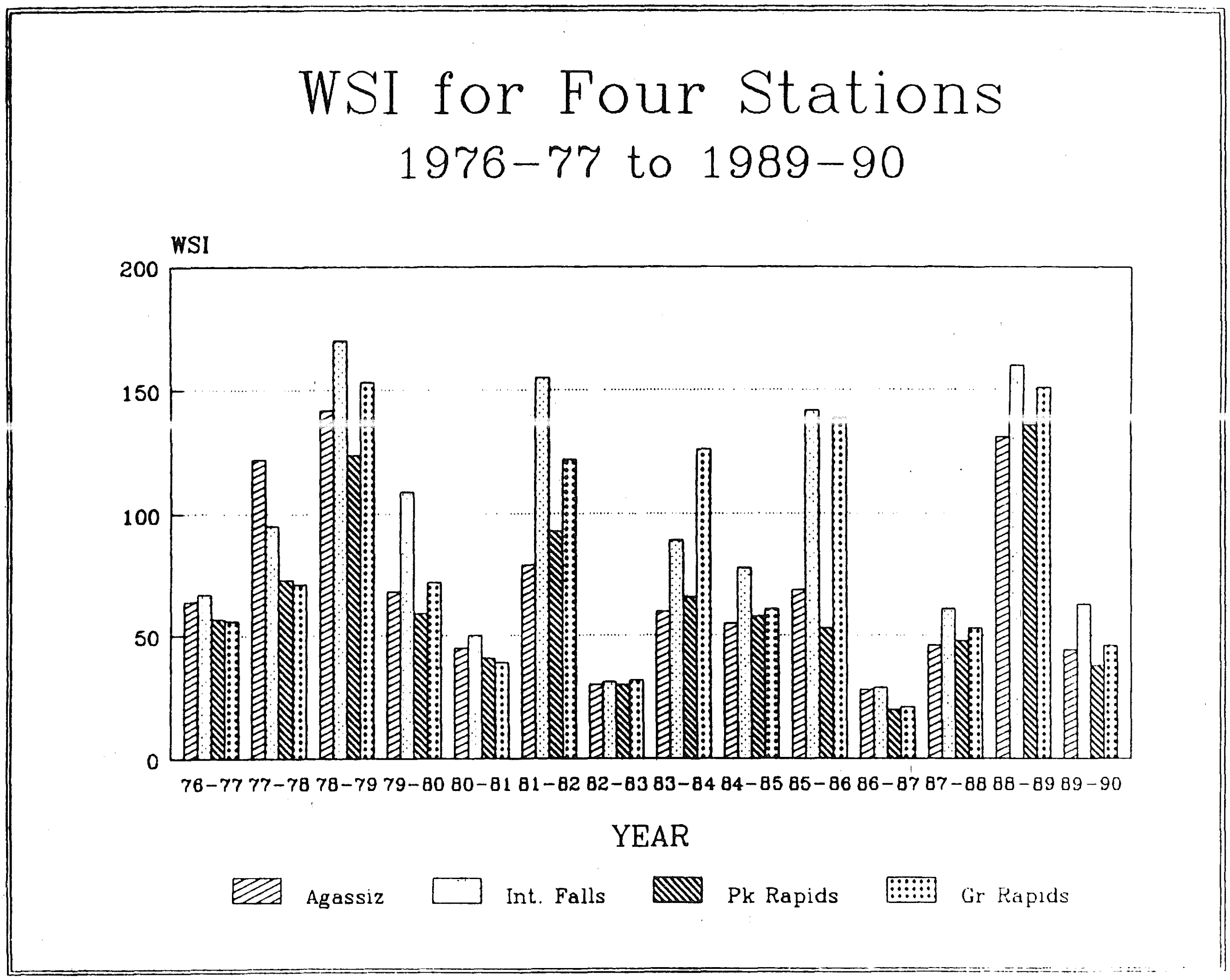


Figure 2. WSI values for four stations, 1976-77 to 1989-90 based on the Wisconsin method.

Snow was deep but not compacted by the first of the year, which resulted in deer being widely scattered and able to move to open feeding areas through late January. By February 1 deer were more restricted to trails under cover that allowed considerable mobility and some access to open feeding areas. By mid-February most managers reported that deer were restricted to heavily packed trails that allowed access over wide areas. In March the reports indicated increased restrictions on movements, but these restrictions may have been due to feeding operations since most of the evaluations were made in areas where deer were being fed. By mid-March, snow depths on south facing slopes began to recede, enabling deer to move off trails and forage more freely. In addition, the combination of warm temperatures settling the snow and cold temperatures refreezing the snow allowed deer to walk without sinking more than 5 inches, even where total snow depth was 18 inches or more.

These reports indicated that weather-related restrictions on deer movement that could have reduced the ability of deer to obtain adequate nutrition were present from mid-January to late-March; a period of 8 or 9 weeks.

Table 1. Winter Severity Indices (WSI) for nine stations, 1988-89 based on the Wisconsin method. The WSI is the summ of days with a minimum temperature of 0 degrees F. or less (shown under the Temp column) and the number of days with more than 18" of snow on the ground (shown under the Snow column).

	Agassiz			Aitkin			Cloquet			Ely		
Week Ending	Temp	Snow	Total	Temp	Snow	Total	Temp	Snow	Total	Temp	Snow	Total
11-Dec-88	4	0	4	5	0	5	4	0	4	4	0	4
25-Dec-88	5	0	9	4	0	9	3	0	7	3	0	7
08-Jan-89	11	2	22	9	3	21	9	8	24	8	11	26
15-Jan-89	6	7	35	4	6	31	2	7	33	5	7	38
22-Jan-89	3	7	45	2	7	40	2	7	42	3	7	48
29-Jan-89	2	7	54	1	7	48	1	7	50	1	7	56
05-Feb-89	5	7	66	5	7	60	5	7	62	5	7	68
12-Feb-89	4	7	77	4	7	71	4	7	73	5	7	80
19-Feb-89	6	7	90	5	7	83	6	7	86	5	7	92
26-Feb-89	5	7	102	4	7	94	4	7	97	4	7	103
05-Mar-89	6	7	115	4	7	105	4	7	108	6	7	116
12-Mar-89	1	6	122	1	7	113	1	7	116	1	7	124
19-Mar-89	5	0	127	4	7	124	4	7	127	5	7	136
26-Mar-89	3	0	130	2	6	132	2	7	136	2	7	145
02-Apr-89	1	0	131	0	0	132	0	3	139	0	1	146
09-Apr-89	0	0	131	0	0	132	0	0	139	0	1	147
16-Apr-89	0	0	131	0	0	132	0	0	139	0	0	147

	Grand Marais			Hibbing			Karlstad			Internat'l Falls			Isabella		
Week Ending	Temp	Snow	Total	Temp	Snow	Total	Temp	Snow	Total	Temp	Snow	Total	Temp	Snow	Total
11-Dec-88	3	0	3	4	0	4	4	0	4	5	0	5	5	0	5
25-Dec-88	2	0	5	6	0	10	4	0	8	6	0	11	8	0	13
08-Jan-89	4	2	11	10	14	34	11	2	21	12	13	36	9	14	36
15-Jan-89	3	7	21	5	7	46	6	7	34	7	7	50	5	7	48
22-Jan-89	2	7	30	2	7	55	4	7	45	3	7	60	3	7	58
29-Jan-89	0	7	37	1	7	63	2	7	54	2	7	69	2	7	67
05-Feb-89	5	7	49	5	7	75	6	7	67	6	7	82	5	7	79
12-Feb-89	3	7	59	5	7	87	4	7	78	5	7	94	5	7	91
19-Feb-89	4	7	70	6	7	100	6	7	91	7	7	108	6	7	104
26-Feb-89	3	7	80	4	7	111	6	7	104	4	7	119	5	7	116
05-Mar-89	3	7	90	6	7	124	6	7	117	7	7	133	7	7	130
12-Mar-89	0	7	97	1	7	132	1	5	123	0	6	139	2	7	139
19-Mar-89	2	7	106	5	7	144	5	0	128	5	7	151	5	7	151
26-Mar-89	1	6	113	2	7	153	3	0	131	4	5	160	3	7	161
02-Apr-89	0	0	113	0	0	153	0	2	133	0	0	160	0	7	168
09-Apr-89	0	0	113	0	0	153	0	0	133	0	0	160	1	7	176
16-Apr-89	0	0	113	0	0	153	0	0	133	0	0	160	1	7	184

RESPONSE TO THE 1989 SITUATION

Cold temperatures and deep snow across the northern portion of the state in December and early January prompted a great deal of concern by both wildlife managers and the general public. The weather conditions and the status of deer populations received extensive coverage by the news media, especially in local newspapers throughout the northern part of the state. In response to questions and concerns raised by the public, a Department news release was issued on January 19 that described the existing winter conditions, stated the Section's intention to monitor deer populations and improve access to deer concentration areas (in case feeding became necessary), and emphasized the Section's desire to delay feeding until conditions made it absolutely necessary.

Regional and Area Wildlife Offices were besieged with telephone calls during this period and, in many cases, issued local news releases to clarify local conditions. In late January, WCCO-TV offered their assistance in obtaining volunteer help and donations to purchase feed. With the Section's approval, the station aired daily spots on the deer situation throughout March. WCCO reported excellent viewer response and collected most of the $15,000 received as donations for the program (Table 2).

In January, the Section began developing a deer feeding operational plan (Appendix 1) that outlined objectives of the feeding project and procedures to be used if a feeding program was initiated. The plan called for the Section to begin feeding on February 24 in those areas reporting the worst deer condition status, unless the weather moderated.

On January 24, $125,000 of Deer/Bear Management Funds that is annually set-aside for winter feeding emergencies was released to Regions 1, 2, and 3 for use in locating deer concentrations (by air), monitoring deer conditions, plowing trails, and purchasing feed from local vendors. Deer/Bear Management funds accrue from a $1 surcharge on the sale of each deer and bear license. This fund usually pays for the computerized lottery systems and most of the mailing and printing charges associated with deer and bear hunting, in addition to the $125,000 that is set-aside each year for emergency winter feeding. In years when feeding is not necessary, this money is released in early spring for use in general deer and bear management activities.

To ensure that feed could be made available by February 24, bids were sent to potential vendors for the pelletized feed on February 3 and were opened on February 16. The amount of feed requested was not specified because of uncertainties associated with weather and funding. Also, in early February letters requesting a supplemental appropriation of $250,000 for purchase of feed were sent to several legislators. The legislature appropriated $300,000 on March 10 (Chapter 8, Laws of 1989) and $260,000 on May 31 (Chapter 300, Laws of 1989). The $300,000 was appropriated from the Game and Fish Fund without conditions of repayment. The $260,000 was considered an advance from the Deer/Bear Management account and has since been repaid with unused deer feeding money from fiscal years 1990 and 1991. Other sources of funding for the 1989 feeding program are shown in Table 2.

A news conference to announce the availability of feed, request volunteer help, and explain procedures to be used in the feeding project was held at DNR Headquarters on February 22. A total of 50 feed depots were set up by area wildlife managers to distribute feed to volunteers, most at DNR offices. Feed was delivered and distributed beginning the week of February 18, and ending the week of April 15. A total of 3,955 tons of feed was distributed during the course of the feeding program in a 46,000 square mile area of northern Minnesota. More than 8,000 volunteers responded to the emergency and donated more than 200,000 hours in distributing feed to deer. Many volunteers also purchased, from private sources, large amounts of additional feed. Landowners in the Red River Valley provided hundreds of tons of sugar beet tailings, sunflower and grain screenings, corn, and hay. The Minnesota Deer Hunters Association reported spending $106,000 on the feeding effort as well as $1,000 to $5,000 from local chapters in northern Minnesota. The Divisions of

Forestry and Enforcement contributed over 4,000 hours and about $50,000 worth of labor and equipment in the feeding effort. In addition County Land Departments, other government units, and private businesses assisted in the program.

Table 2. 1989 Deer Feeding Funding Sources (as cost coded by field offices)

Fund Description	Primary Use	Dollars Contributed
Beltrami Island Federal Lease	Salaries	$ 3,117.58
Comprehensive Fish & Wildlife Planning	Salaries, Feed	5,603.35
Computerized Licensing Fund	Feed, Equipment, Overtime	789,365.61
Deer Habitat Improvement	Salaries	41,919.14
Wildlife Acquisition-License	Salaries	4,389.44
Deer Feeding Gift Account	Feed	14,500.00
Wildlife Management	Salaries, Feed, Equipment	114,961.49
Other Funds	Miscellaneous	25,010.49
TOTAL		**$976,367.10**

RESULTS - PUBLIC RELATIONS/EDUCATION BENEFITS

The 1989 winter emergency deer feeding project provided some of the most positive public relations that the Section of Wildlife has ever achieved. There are, of course, criticisms about how various details were carried out but the publicity given the Section and Department was basically positive. In part, this was due to a public awareness that the Department was doing something direct and positive to address a problem.

The feeding program also brought Wildlife personnel into closer, more prolonged working relationships with numerous sportsmen's clubs and individuals. This is likely to have promoted understanding and better relationships and has carried over to work on other wildlife species as well.

Other benefits that resulted from the feeding program included public education regarding deer habitat and deer management. Also, although the feeding program interfered with on-going forest habitat management coordination, there were several work areas where the benefits of Wildlife and Forestry working together in other ways was recognized.

Some wildlife managers were provided the opportunity to spend more time on deer management activities such as flying to locate deer concentrations and observation of deer behavior in relation to winter conditions. This is especially valuable because deer do not normally receive as much attention as warranted in some parts of the state due to staffing shortages and funding constraints.

In farmland areas deer depredation on standing or stored crops is often a problem and is increased in severe winters. The deer feeding program may have averted what otherwise would have been a large deer depredation problem with its resultant heavy demands on Wildlife personnel time. This is also a public relations benefit to the Department and an economic benefit to these farmers who may have experienced losses to deer without the emergency feeding.

Finally, the outpouring of contributions and the overwhelming volunteer effort that was observed demonstrated the value of the deer herd to Minnesota's citizens and heightened awareness of the importance of deer and the recreation provided by deer in the state.

RESULTS - DEER FED

NUMBER OF DEER FED: For this report, Deer Management Units (DMUs) were used as the geographic basis for analysis. DMUs were grouped as either farmland or forest to further facilitate analysis (Figure 3). The Deer Management Units where feeding took place are described in Appendix 2. Deer populations in Minnesota are regulated from the basis of Antlerless Permit Areas within each DMU. A computerized model is maintained for each Permit Area which show estimated and future deer populations in response to variables such as births, sex ratios, age structure, and various forms of mortality. Use of these models allow Wildlife Managers to establish harvest quotas for antlerless deer in each Permit Area. Such models have provided deer population estimates in DMUs where feeding took place in 1989. Records kept by DNR employees who supervised the distribution of feed were used to determine the amount of feed delivered to each DMU.

Research shows that 2.0 to 2.9 pounds of pelleted deer food per day are required to maintain a deer in good nutritional condition during winter (Ozoga and Verme. 1985, Voight pers. comm.). For this analysis, it was assumed that each deer benefitted by the feeding program required 2.5 lbs. of feed per day. Using this figure and information concerning the number of days feed was available and the amount of feed delivered, the maximum number of deer fed in each DMU was determined (Table 3). This is a maximum estimate because there was waste, such as spoilage, feed placed where deer do not find it, and feed found but not eaten by deer. Because we could not determine the amount of feed consumed or lost, we assumed that deer consumed all feed that was distributed, that all deer fed had adequate feed for the duration of the program, and all deer (fawns, does, and bucks) had equal access to feed.

We calculate that 9.3 percent (54,038 deer) of the forest deer and 22.3 percent (18,924 deer) of the farmland deer found within DMUs where feeding took place, could have been fully fed during the distribution period (Table 3). Overall, for northern Minnesota 11 percent (72,962 deer) of the deer population could have been fed during this program.

The proportion fed varies greatly among the DMUs in both the forest and the farmland. To a large extent this variation is due to the number of

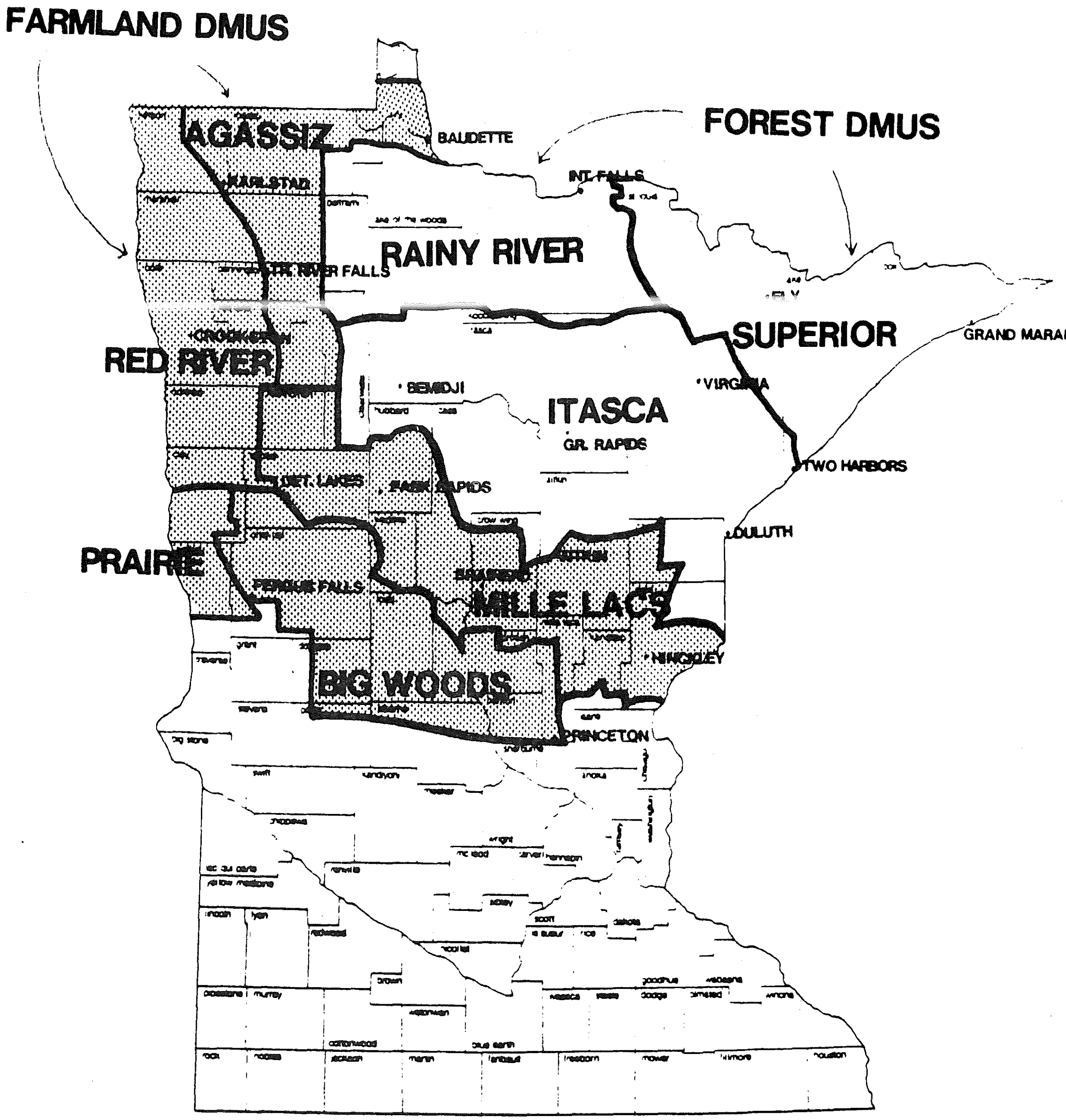


Figure 3. Deer Management Units (DMUS) in the Farmland (shaded) and Forest Areas - 1989 Emergency Deer Feeding Program.

volunteers in the respective areas combined with the distribution and accessibility of the deer. In the forest a larger proportion of deer were fed in areas with high human populations or areas where deer were concentrated and there was extensive feeding of deer (as a hobby) already taking place such as the Superior DMU. In most farmland DMUs, the proportions fed were much higher because deer were more accessible and were found in isolated groups that were easy to locate.

Table 3. 1988 Pre-Winter Deer Populations and Deer Fed by DMU, 1989 Deer Feeding Emergency.

DMU	Area (Sq. mi.)	1988 Pre-Winter Deer Density (Deer/mi.[2]	1988 Pre-Winter Deer Population	Lbs. Feed Distributed	Maximum No. Deer Fed[1]	Maximum % Deer Fed
Rainy River	6,156	20.1	123,887	609,000	5,412	4.4%
Superior	5,310	15.0	79,564	965,800	10,229	12.9%
Itasca	10,677	23.2	247,478	2,585,600	24,999	10.1%
Mille Lacs	8,896	14.9	132,540	1,562,800	13,398	10.1%
Forest Subtotal	31,039	18.8	583,469	5,723,200	54,038	9.3%
Agassiz	4,083	7.1	29,170	921,600	7,518	25.8%
Red River	5,207	3.5	18,212	812,000	6,623	36.4%
Prairie	1,344	2.2	3,001	156,000	1,783	59.4%
Big Woods	4,566	6.9	31,555	298,600	3,000	9.5%
Farmland Subtotal	15,200	5.4	81,938	2,188,200	18,924	22.3%
Total	46,239	14.4	665,407	7,911,400	72,962	11.0%

[1]Based on lbs. of feed distributed assuming that 1) each deer needed 2.5 lbs/day, 2) deer consumed all feed distributed, 3) all deer had adequate feed for duration of the program, 4) all deer (fawns, does, and bucks) have equal access to feed.

Reports submitted by field offices also provided information regarding the number of deer fed by week by permit area (Figure 4). This data shows that the maximum number of deer that were fed based on the amount of food delivered in any one week was 80,160 during the week of March 4 to March 10, but decreased weekly through the end of the feeding program. Past experience has shown that if emergency feeding programs are initiatead too early in winter, volunteer effort is often insufficient to sustain the program as long as necessary. This analysis shows that by starting feeding in late February, the DNR was able to extend a significant volunteer effort through March.

The amounts of feed delivered to various DMUs does not include feed purchased by individuals or private groups such as the Minnesota Deer Hunters Association (MDHA), which purchased a considerable amount of pelletized deer feed. In the Red River Valley landowners and other individuals provided large quantities of sugar beet tailings, sunflower screenings, corn and hay. However, accurate records of such feeding were not available and thus, the estimated number of deer fed does not account for deer fed by private groups.

It is important to differentiate between supplemental deer feeding and an emergency feeding program. Many individuals and organizations provide supplemental food for deer throughout most winters as a form of recreation or to benefit small, local populations of deer. The extent of this activity is unknown, but is widespread in some areas, especially along the North Shore and near urban areas. Supplementary feeding can reduce winter deer mortality, increase fawn production, and reduce the need for emergency feeding, which is done only during severe winters. Emergency feeding is not started until late in winter to reduce costs and ensure that feed will be available as long as required by deer. Many managers reported that much of the state-purchased deer feed went to individuals who were aleady feeding deer, mostly on private lands. In most cases, these individuals would have continued to feed even if the state program was not initiated. While the state feeding program certainly reduced the cost of these private feeding efforts, the benefit to the public and to the deer population was negligible in these areas.

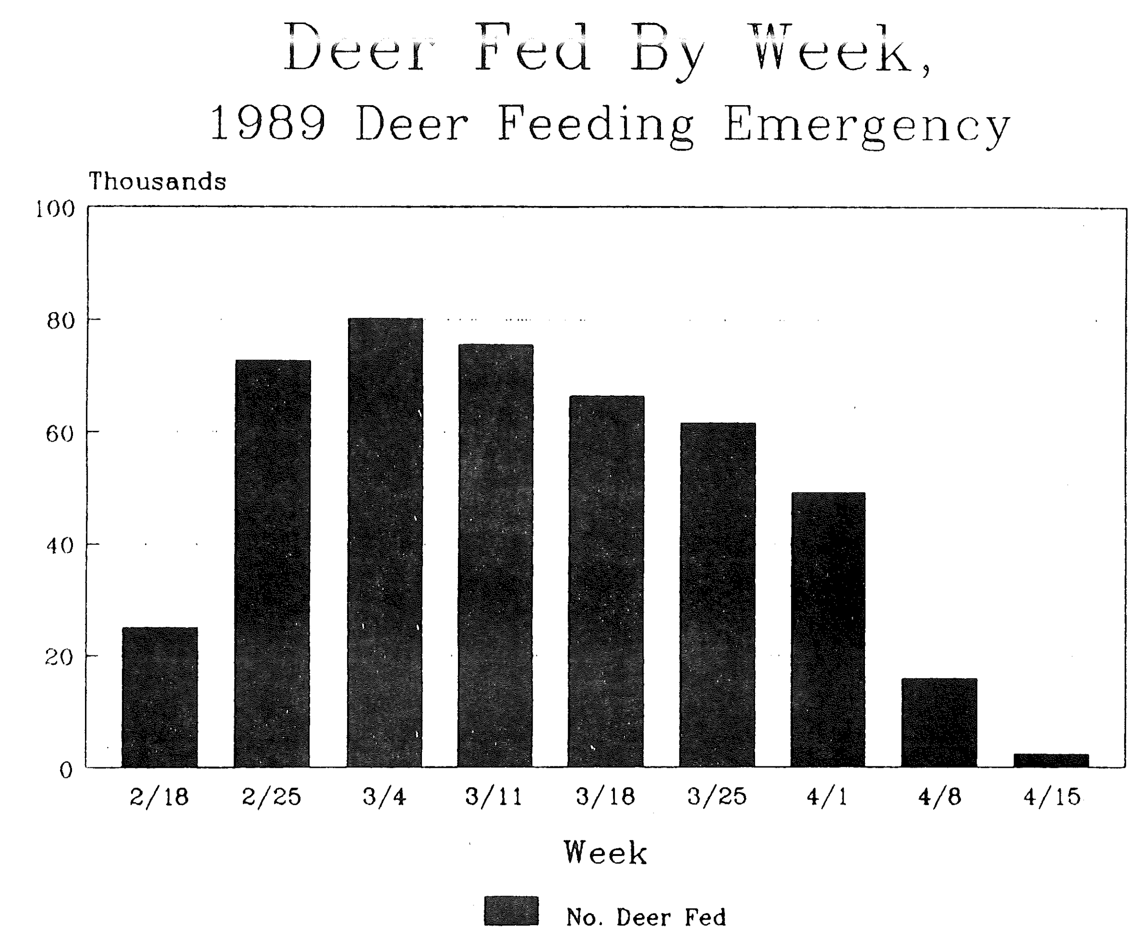


Figure 4. Deer Fed by Week, 1989 Emergency Deer Feeding Program.

IMPACT ON DEER POPULATION: The legislation that initiated this report required the "study of costs of deer feeding and its affect on deer populations". An answer to this question goes beyond the fact that a properly formulated deer feed can provide adequate nutrition and that such feed delivered to a small group of deer can benefit deer during a severe winter. This question requires the analysis of the impact of winter feeding, not on individual deer, but on the entire population in DMUs or larger areas in which the Section of Wildlife will base future deer feeding decisions.

To answer questions about how population parameters interact with the proportion of deer fed, Lenarz (Appendix 2) simulated the effects of emergency winter feeding on white-tailed deer populations by means of a computer analysis, which forms the basis for this section of the report.

This analysis assumes that deer that were fed suffered normal winter mortality while deer that were not fed suffered much higher levels of mortality. The model estimates the number of deer saved by feeding (the difference between normal and high levels of mortality) and increased survival of fawns born the following spring to does that were fed. Based on information provided by Area Wildlife Managers concerning the number of deer fed in each Permit Area, and the computer model developed by Lenarz, it was possible to compare the fall, 1989 deer population with and without the DNR feeding program in both the farmland and the forest. Fall, 1989 populations were compared because these numbers would be of primary interest to deer hunters, who paid most of the costs of the deer feeding program.

This analysis shows that even with a widespread feeding program, deer populations in all DMUs declined due to the severe winter weather. However, the feeding program was able to moderate the impact of the winter on deer populations.

In forest DMUs, it was found that there were an additional 16,196 deer available in the fall of 1989 as a result of the feeding effort than would have been available without feeding (Table 4). The 1988 post-harvest deer population in forest DMUs was 583,469 and the model showed that without feeding, the population in the fall of 1989 prior to the deer season would have been 520,490 compared to 536,686 with the feeding program. The proportion of additional deer attributable to feeding averaged 3.1% in the forest and ranged from 1.8% in the Rainy River Unit where a low proportion of deer were reached by the feeding program, to 4.8% in the Superior DMU where a higher proportion of deer were fed. This represents an additional .6 deer/mi.^{2} due to DNR deer feeding in the forest.

In farmland areas, a much higher proportion of deer were reached by the feeding program and the impact of the feeding on deer populations was more significant. The total 1988 post-harvest deer population in those DMUs where feeding took place was 81,938 and the model indicated that, by fall, 1989, this population would have been 65,357 without feeding compared to 70,060 with the feeding program (Table 4). This is an increase of 4,703 deer, or a 7.2% increase in deer numbers, due to the feeding program in the farmland. Increases ranged from 2.9% in the Big Woods DMU along the southern boundary of the feeding area where very little feed was distributed, to 18.6% in the Prairie Unit where a high proportion of the deer population was reached. Thus, even though there were only .3 deer/mi.^{2} added to the farmland deer population as a result of feeding compared to .6 deer/mi.^{2} in the forest, the impact to the farmland population was much greater than in the forest because of lower deer densities. In effect, the significance of a 1 deer/mi.^{2} increase is much greater in the farmland than in the forest.

This analysis does not evaluate the impact of the feeding program in years after 1989. It was felt that there were too many variables affecting deer numbers after 1989 including harvest during the 1989 hunting season, winter weather, etc. In fact, most areas of northern Minnesota had record

Table 4. Evaluation of 1989 Emergency Deer Feeding Program.

DMU	1989 Pre-Harvest Deer Population W/O Feed[1]	W/ Feed[2]	Add'l Deer[3]	% Add'l Deer	Cost	Cost/Add'l Deer[4]	Cost/Deer Fed	Feeding Eff.[5]
Rainy River	110,961	112,957	1,996	1.8%	$95,672	$47.93	$17.68	$86.30
Superior	68,290	71,571	3,281	4.8%	$136,220	$41.52	$13.32	$53.40
Itasca	219,662	226,867	7,205	3.3%	$357,236	$49.58	$14.29	$101.40
Mille Lacs	121,577	125,291	3,714	3.1%	$195,275	$52.58	$14.57	$70.80
Forest Subtl.	520,490	536,686	16,196	3.1%	$784,403	$48.43	$14.52	$81.50
Agassiz	23,295	25,363	2,068	8.9%	$134,873	$65.22	$17.94	$37.10
Red River	11,895	13,304	1,409	11.8%	$97,713	$69.35	$14.75	$15.90
Prairie	2,219	2,632	413	18.6%	$18,249	$44.19	$10.23	$7.30
Big Woods	27,948	28,761	813	2.9%	$36,254	$44.59	$12.08	$27.40
Farmland Subtl.	65,357	70,000	4,703	7.2%	$287.089	$61.04	$15.17	$26.20
Total	585,847	606,746	20,899	3.6%	$1,071,492	$51.27	$14.69	$64.40

[1]1989 Pre-harvest deer density if no feeding had taken place.
[2]1989 Pre-harvest deer density with feeding.
[3]Additional deer in 1989 as a result of feeding.
[4]Cost for each additional deer in the 1989 Pre-Harvest Population due to the feeding program.
[5]Feeding efficiency = $\frac{\text{Total Cost X 10}}{\text{\% Add'l Deer * Area (sq. mi.)}}$ and is a measure of the cost to raise the 1989 pre-harvest deer population by 10% in each mi.^{2}.

deer populations ~~and~~ harvests by 1990. This was primarily a result of a very stable and healthy deer population preceding the 1988-89 deer emergency, rather than effects of the 1989 feeding program. The age and sex structures of a deer population can greatly influence how quickly populations can recover from winter losses. When there are abundant female deer and a young age structure, the population is better able to recover from a severe winter. The deer herd in northern Minnesota entering the winter of 1988-89 was in excellent condition in most areas due to conservative numbers of antlerless permits in the previous two to five years. Permits were also reduced in many areas for the 1989 season, and the deer population recovered very quickly.

RESULTS - COSTS

DIRECT COSTS: This section of the report documents the expenditure of time and material by DNR (primarily Wildlife) employees as a cost in dollars and volunteers. A total of $281,359 by Wildlife and $49,597 by other DNR personnel were expended to distribute over 3,955 tons of feed valued at $744,536 (Table 5). More than 8,000 volunteers worked to distribute the feed without cost to the State. Excluding the value of the volunteer effort, a minimum of $1,071,492 in state funds was spent on the 1989 winter emergency deer feeding program.

Table 5. Summary of costs and volunteer effort, 1989 Emergency Deer Feeding Program.

DNR Region	Section of Wildlife Hours	Section of Wildlife Cost	Other DNR Hours	Other DNR Cost	Pellet Feed Tons	Pellet Feed Cost	Total Cost	Volunteers Persons	Volunteers Hours
1 (Northwest)	4,968	$118,650	1,102	$17,216	1,721.5	$323,642	$459,508	2,325	60,000
2 (Northeast)	5,074	$104,257	2,592	$19,591	1,365.5	$256,714	$380,562	3,545	117,081
3 (Central)	3,712	$58,434	393	$8,790	873.3	$164,180	$231,422	2,190	53,050
Total	13,754	$281,359	4,087	$49,597	3,955.7	$744,536	$1,071,492	8,060	230,131

The major activities by Department staff associated with the feeding effort and their costs included locating deer concentrations ($29,290), coordinating feed shipments from suppliers ($17,550), distributing feed ($91,050), handling publicity and public inquiries ($26,860), general coordination and supervision ($22,100), and other costs including equipment rental, trail dozing, and fleet management ($45,120) (Figure 5).

COST TO OTHER PROGRAMS/WORK NOT DONE: Wildlife personnel in northern Minnesota spent 13,754 hours on the 1989 winter deer emergency feeding program. These hours are equivalent to 34 persons working full time for 10 weeks. In addition, other DNR personnel, primarily from the Divisions of Forestry and Enforcement, spent approximately 4,000 hours on the program. The time donated by approximately 8,000 volunteers is difficult to determine but local wildlife managers have estimated the total at more than 230,000 hours.

Wildlife Managers were unable to complete a number of activities due to the time and money spent in the feeding effort. The activity that suffered most was Forestry/Wildlife interdivisional coordination including timber sale design review and field checks, forest stand map updates, forest development planning and review, timber management planning, Forest Unit planning, and general Forestry/Wildlife interaction. The amount of technical assistance provided to private forest landowners was greatly reduced as was time spent on the computerized forest habitat evaluations that form the basis for most management activities.

On-the-ground habitat improvement work was also delayed or not completed due to the emergency feeding program including mechanical regeneration of aspen, prescribed burns, brush shearing, moose habitat improvement projects, and planning and development on Wildlife Management Areas (WMAs). Because of the seasonal nature of many habitat improvement projects, winter months are very important for planning and preparing for spring, summer, and fall field work and a number of projects on public lands were cancelled or delayed because of the feeding project.

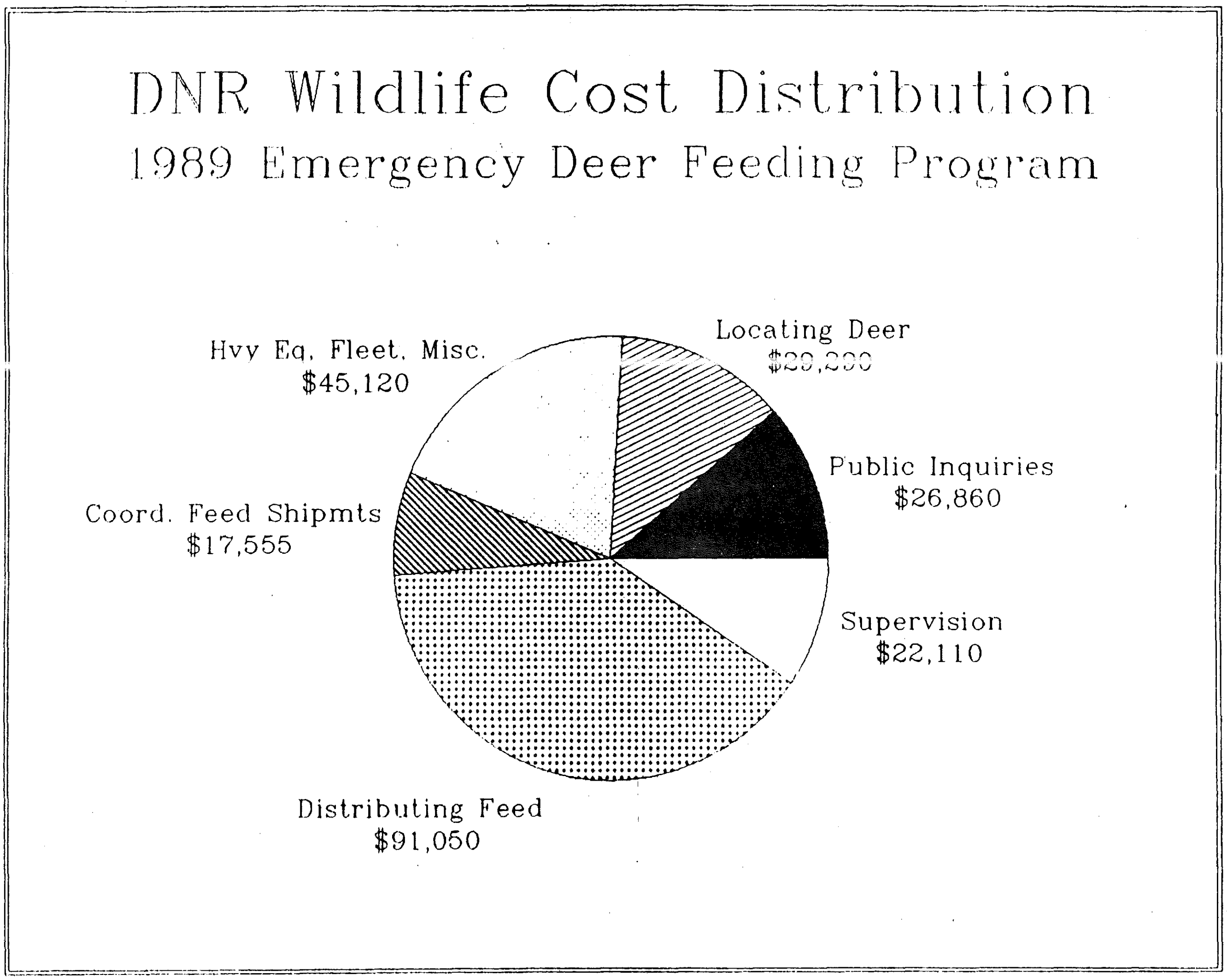


Figure 5. Section of Wildlife Activities in Costs, 1989 Emergency Deer Feeding Program.

<u>COST PER DEER FED AND FEASIBILITY OF FEEDING</u>: The expenditures noted in Table 5 provide a means of converting the costs recorded on a Wildlife office basis to a cost per deer fed in each DMU (Table 4). These costs are relatively constant and range from $10.23 in the Prairie DMU to $17.94 in the Agassiz Unit and averaged $14.69 per deer fed.

It might be expected that feeding deer in the farmland would cost less per deer because the deer are more accessible. However, average costs per deer fed in farmland DMUs was $15.17, 4.5% more than the $14.52 per deer fed in the forest. This was due to the fact that since most of the feed was distributed by volunteers, the costs to the DNR were primarily the actual cost of the feed (about $.235 per deer per day), and the cost for DNR employees to distribute feed to volunteers and these costs are relatively constant between Units.

Nevertheless, feeding deer is more feasible in the farmland than in the forest because a higher proportion of the deer can be reached. As mentioned previously, a maximum of 22.3 percent of the farmland deer versus 9.3 percent of the forest deer could have been fed based on the amount of DNR purchased food that was distributed (Figure 6). This resulted in a greater impact to the following fall's deer population in farmland units (7.2% increase due to winter feeding) than in the forest units (3.1% increase due to feeding) (Table 4). A feeding efficiency equation (Table 4) was developed to evaluate the

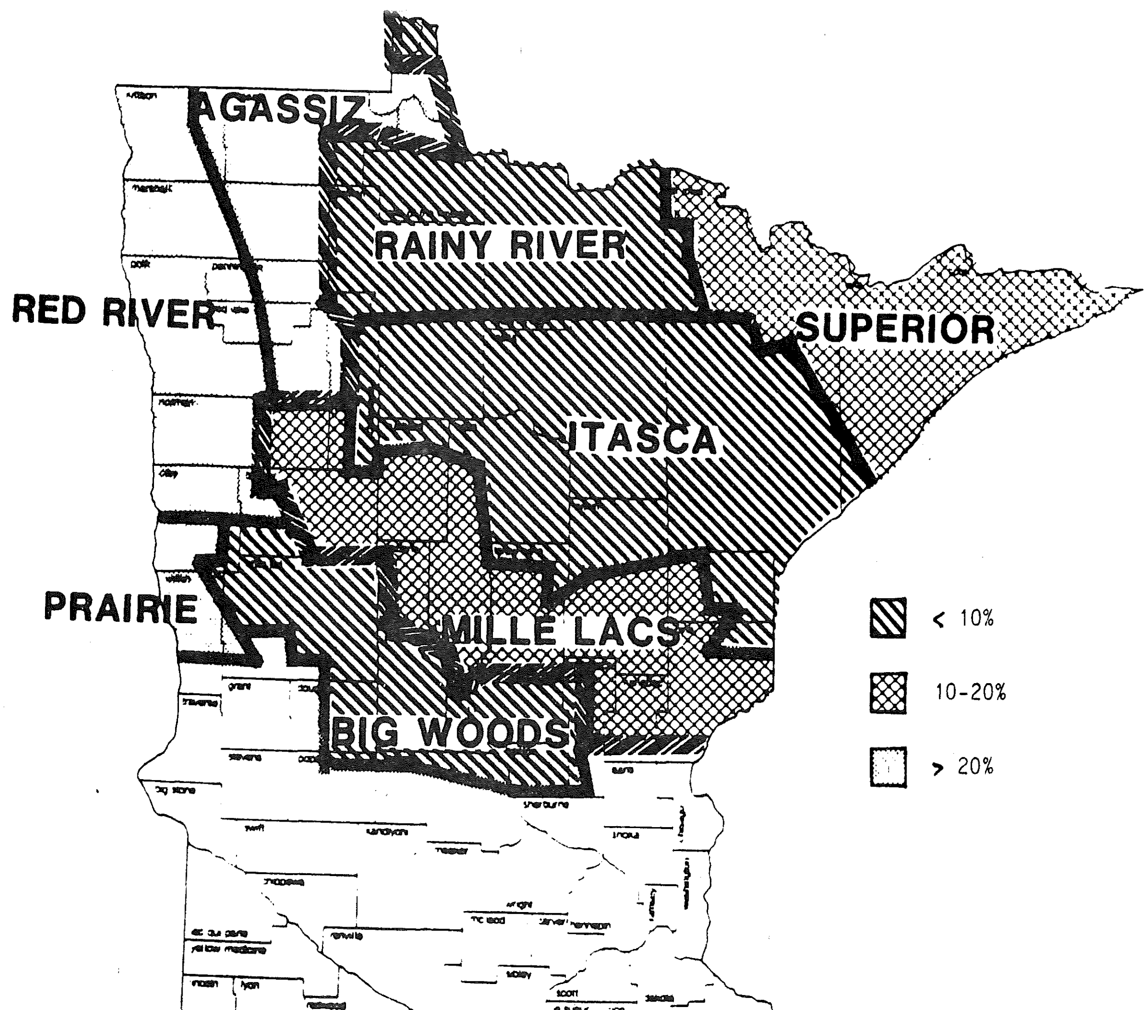


Figure 6. Proportion of Deer Fed by DMU, 1989 Deer Feeding Program.

cost (on a square mile basis) associated with each 10% increase in the fall, 1989 deer population due to the feeding effort. A 10% increase was chosen under the assumption that this represents the minimum increase in the following fall's population that would be noticeable by hunters. Feeding efficiency was more than three times higher in farmland units (average of $26.20 per 10% increase in the population) compared to the forest (average of $81.50 per 10% increase) and ranged from $7.30 in the Prairie DMU to $101.40 in the Itasca Unit.

CONCLUSIONS

1. The response by DNR staff and volunteers during the 1989 emergency feeding program was unprecedented and probably represents the maximum effort possible for a winter feeding program. Because of the early onset of severe winter weather and the widespread publicity that accompanied the 1989 program, it is unlikely that a larger number of volunteers could be mustered for future feeding efforts. Also, the amount of time spent on the program by DNR staff probably was the maximum possible without seriously impairing other Department or Division of Fish and Wildlife activities and responsibilities. However, it is likely that with improved coordination of feed shipments and availability of feed, additional feed could have been distributed in some units.

2. Without volunteer help, an extensive winter feeding program would be impossible. The 230,000 estimated volunteer hours spent feeding deer is almost 13 times the 17,841 hours spent provided by DNR staff. An example of the expense of feeding deer without volunteer help is provided by the Mille Lacs State Wildlife Management Area, a large block of public land where most feeding was done by DNR staff. In that area the cost per deer fed was $76.87, more than five times the cost to feed deer in areas with extensive volunteer labor.

3. State-funded feeding programs should be considered only in those winters and in those areas where it is most effective and necessary, for the following reasons: a) it is extremely expensive to feed deer; b) important long-term management activities are not accomplished when winter feeding programs are initiated; and c) the effectiveness of deer feeding is highly variable in different parts of the state. If the severity of winter or the availability of food and cover are such that feeding would not result in significant benefits to deer populations, such efforts are a waste of both time and money. Similarily, attempts to feed in areas where accessibility of deer is low and volunteer help is limited reaches few deer and benefits to deer populations are minimal.

4. All of the surrounding states and provinces have developed or recommended policies that are opposed to state-funded winter deer feeding programs, except that North and South Dakota and Manitoba do some feeding in farmland areas to prevent crop depredations or deer starvation. In Michigan and Wisconsin, where habitats are similar to much of Minnesota's forest areas, private feeding efforts are reported to have some localized value, but state-funded feeding programs are considered ineffective and are not undertaken.

5. Despite the demonstrated effectiveness of feeding for benefitting localized deer concentrations, the measure of the effectiveness of a deer feeding program as a management tool is the benefit to deer populations over a deer management unit (DMU)-sized area, or larger. The Department can only implement feeding over relatively large geographic areas where there is the potential for significant population effects and where the DNR can monitor, evaluate, and manage deer populations for the benefit of large numbers of people. The effectiveness of feeding as a deer management tool is primarily a function of the proportion of deer reached by DMU. In those DMUs where deer are easily located and accessible, and where sufficient volunteer help is available, a high proportion of deer can be reached and benefits to the deer population may be significant in some winters. In other Units where accessibility to deer is low and/or volunteer help is limited, benefits to the deer population and the general public are limited.

6. The need for emergency feeding programs can be reduced by enhancing year-around deer habitat. In forest DMUs, increased timber harvests combined with an accelerated deer habitat improvement program in the past 20 years has resulted in improved summer and winter food resources. These long-term habitat efforts have reduced the potential for large-scale deer losses during severe winters. In farmland DMUs, management of deer habitat is more expensive and difficult. In contrast to forest units, most of the land in farmland areas is in private ownership. Establishment or purchase of winter food plots on public and private lands is the primary method for improving deer habitat in the farmland. This practice is expensive with high annual costs and consequently, the Section has been unable to fund a sufficient acreage and distribution of food plots to make winter feeding unnecessary.

7. While the cost per deer fed is very similar in both farmland and forest areas, the cost to increase the following fall's deer population by 10% is more than three times higher in the forest than in the farmland. These values are crucial in determining when and where public funds (and deer hunter funds) should be used to feed deer.

8. This analysis shows that despite the most widespread and expensive deer feeding program ever initiated in Minnesota and perhaps North America, deer populations decreased due to the winter weather, even in those areas where the proportion of deer fed was high. The analysis also shows that properly managed deer populations can recover quickly from winter deer losses.

9. Based on these findings, emergency winter feeding of deer is feasible in the Agassiz, Red River, and the northern portion of the Prairie DMUs and may be justified under certain conditions. Deer in these farmland units are heavily dependent on agricultural crops for food; have relatively limited or poor quality winter cover available; occur at much lower overall densities than in forested areas; and experience a high potential for severe population losses when deep and/or crusted snow and extensive crop harvests limit food availability. Under these conditions, a generally high proportion of the deer population can be accessed by emergency feeding efforts and benefits to deer populations over a broad geographic area can be demonstrated.

10. This analysis also indicates that emergency winter feeding of deer is <u>not</u> feasible in the Rainy River, Itasca, and Mille Lacs DMUs due to the difficulty in locating and accessing large numbers of deer in these forest DMUs and the limited availability of volunteers in these Units. Forest deer populations are better able to withstand and recover from severe winters than farmland populations because of generally higher deer densities and greater food availability. This analysis has shown that the 1989 feeding program was not able to reach a high enough proportion of deer to result in significant deer population increases in these Units and the cost for the small addition to deer populations the following fall was excessive.

11. Results of this analysis show that feeding may be feasible in the Superior DMU. Deer in this Unit are very concentrated in traditional wintering areas and extensive recreational deer feeding already takes place along the North Shore of Lake Superior each year. Feeding efficiency is higher in this unit because a higher proportion of deer can be reached in these concentration areas. However, deer are absent from much of this unit due to deteriorating habitat conditions for deer and supplemental and emergency feeding of deer may act to artificially maintain deer populations in this unit. Consequently, the advisability of feeding deer in this DMU is questionable.

12. It is not possible to assess the feasibility of feeding deer in the Big Woods DMU in this analysis because the availability of feed was not uniform in this area. This was due to the fact that the southern boundary of the emergency feeding program bisected this Unit and the amount of feeding that took place was not the maximum possible. However, accessibility of deer is similar to the Agassiz Unit and it is anticipated that the feasibility of feeding in the Big Woods DMU would be similar to this unit.

13. In those areas where state-funded feeding programs are not feasible and justified, privately funded feeding efforts can benefit small, local deer populations.

RECOMMENDATIONS

1. Future state-funded winter deer feeding programs in the northern part of the state should only be undertaken in the Red River, Agassiz, northern Prairie, and possibly the Big Woods DMUs, and only when the Department determines that weather and/or food conditions warrant such an action.

2. Future state-funded winter deer feeding programs must use volunteers for distribution of feed to deer. Feeding programs should be initiated as late in winter as possible to reduce costs and maintain volunteer effort while still providing benefits to deer populations.

3. State-funded feeding programs should be designed to supplement, rather than replace, private feeding efforts. A survey should be undertaken to determine the extent of private feeding activities in the various areas of the state.

4. During severe winters where state-funded feeding programs are not warranted, the DNR should assist private individuals and groups interested in feeding by providing information on the location of deer concentrations and information concerning how, when, and what to feed.

5. Monitoring of deer conditions and deer populations during winter should be intensified, and research on new techniques and strategies to assess the effect of winter weather on deer survival and deer populations should be developed.

6. Efforts to improve and protect both summer and winter deer habitat should be expanded to mitigate the effects of winter weather and reduce the need to implement feeding programs. Additional research should be undertaken to determine the cost-effectiveness of deer habitat improvement projects and their effect on winter deer survival and fawn production, so that 2further assessments can be made regarding future directions for deer management in the state.

7. Deer populations should continue to be managed at appropriate levels to minimize damage to agricultural crops, natural foods, and cover, and to allow deer populations to recover quickly from severe winters.

8. Efforts to educate the public on deer feeding issues, and deer biology and management should be increased.

9. The findings of this report should be incorporated into an emergency deer feeding policy that would guide future decisions concerning winter feeding.

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APPENDIX

Appendix 1. Section of Wildlife Operational Deer Feeding Plan.

Operational Plan
Deer Emergency Feeding Project
Winter 1989
Section of Wildlife

I. Status

Snow depths in excess of 18 inches have persisted in much of northern Minnesota since late December. This combined with extended sub zero temperatures indicates that an extensive feeding program by March 1st is very probable. It will require strong commitment of the Section's northern field staff, along with the help of hundreds of volunteers to distribute pellitized deer feed, and $450,000 (assuming we try to reach 10 percent of the herd). This will require excellent coordination, communication and cooperation.

II. Background

By January 10, 1989, snow depths of 24 to 30 inches were recorded in much of the northern deer range, north of a line roughly from central Pine County due west to central Wilkin County with even greater depths in northern Cass and Itasca Counties, along the north shore, and in the western fringes of the Red River Valley ranged from 6 to 18 inches more (See Appendix 1). Because extreme snow depths occurred earlier than normal, the potential need for artificial feeding increased. A DNR news release dated January 12, indicated the need for concern; stated the Department's intention to increase monitoring and to improve access, and emphasized that it is important not to begin feeding efforts until needed. (See Appendix 2).

From the January 23 through January 31, 8 days of unusually mild temperatures (high reported in Bemidji to 40° F.) occurred across the state. This extended warmth reduced snowdepths by up to 1 foot in some areas; most notably in northern Cass and Itasca Counties (See Appendix 3). It was hoped that in addition to this reduction in depth, the snow would have compacted so that deer movement would be less restricted. Unfortunately, penetrometer readings throughout t he northern deer range indicate that the existing snowpack gives very little support to deer, so deer movement remains quite restricted (See Appendix 4).

An estimated total winter population of 475,000 deer is affected by the deep snow conditions. Of that total, approximately 20,000 deer in the Red River and Agassiz Deer Management Units (northwest prairie and transition areas) must also contend with poor cover and food conditions because the 1988 drought reduced crop yields and allowed for more fall plowing.

During a normal winter, approximately 17% of the deer herd perishes, primarily affecting the previous years fawns. During a severe winter with deep snows and extreme cold, such as we are now experiencing, the mortality rate may reach or exceed 35%, again primarily affecting fawns (See Appendix 5). The number of antlerless deer permits (quota) offered during hunting season is annually adjusted for these changing rates of winter mortality, so that reduced harvest of does and fawns allows the herd to rebuild to goal levels as soon as biologically possible after a severe winter.

On January 24, 1989, $125,000 of Deer-Bear Management money that is annually set aside for deer feeding or depredation emergencies was released to the three northern DNR Regions. This money was authorized for locating deer concentrations and monitoring deer conditions, plowing trails, and local purchases of deer feed in the event that feed was needed prior to the shipment from large vendors (See Appendix 6). Most of this money will be spent before March 1. Therefore, the Section of Wildlife intends to seek an advance appropriation of $250,000 on next biennium's deer-bear feeding money. If feeding occurs throughout the northern part of the state and extends through April 15, an additional $250,000 special appropriation from the legislature may be needed (assuming our objective is maintained).

III. Objective

To provide adequate feed to not less than 10 percent and 50 percent of the wintering deer herds in the northern forest and northern prairie regions, respectively.

IV. Project Priority

Section of Wildlife staff must prepare for an extensive feeding program. Because it will require considerable area and regional planning, coordination with volunteers, monitoring, access improvement and the distribution of feed, this project must receive the highest priority.

V. Timing

We should be ready to begin feeding on February 24th in the highest priority sites. Regional Coordinators are responsible for supplying these depots first. Vendors should be notified by the Regional Coordinators of these priorities. All other locations should be ready by March 3. Fridays were selected to make maximum use of volunteer services, including volunteers who will travel from other portions of the state for the first weekend of effort. When the decision is made to begin feeding, notice will be provided to the Regions by Fax before this notice is released to the media.

VI. Coordination/Organization

A. The establishment of clear lines of communication and defined roles and responsibilities is essential to maximize the effectiveness of a feeding program and to minimize misinformation. These will be structured as follows:

Project Coordinator - LeRoy Rütske (Backup - Bremicker) 612-296-3344

Region Coordinators (See Appendix 7)	1 Leon Johnson - Backup, Rob Naplin 2 Ken Kramer - Backup, Bob Chesness 3 Dennis Hanson - Backup, Henry Wulf
Area Coordinators (See Appendix 7)	1 all area and unit managers except Scharf and Larson 2 all area managers 3 all area and unit managers except Maurer and Schad

Lines of Communication

Area and Units must contact Regional Coordinators, Regional Coordinators will contact Rutske.

B. Additional Personnel

Regional 1, 2, and 3 managers should reassign staff as needed. Regions 1, 2 and 3 requests for additional staff should be made through the Operations Manager.

VII. Monitoring

Increased aerial, ground, weather and snow monitoring began on January 17th. Area and major unit observations must continue to be submitted to Regional Coordinators by Friday of each week. Regional coordinators should compile this information and Fax it to St. Paul, before 12:00 noon each Friday. Lenarz should continue to receive snow depth and penetrometer readings from area managers by telephone on each Monday and Fax this information the same day to St. Paul. Deer Winter Condition Continuing Evaluation forms were sent to Regional Coordinators earlier and should continue to be forwarded to St. Paul through the Regional Coordinator.

VIII. Access Development/Improvement

Because wintering deer are widely scattered and movements are very restricted, considerable effort must be made to improve access to potential feeding sites. In addition to the use of Wildlife and other Division equipment, DOT has provided a list of contractors that are already under State contract. A list and instructions on how to use these contractors is attached (See Appendix 8).

Contact will be made by the Central Office on February 6 for the use of some National Guard Units. It is hoped that they will see this as an opportunity for additional training experience and will make their equipment and manpower available. Because most units mobilize on weekends, we expect that advance contact and planning with area or regional staff will be needed once the go ahead is given. Central office will supply the list of units and contact persons to regional coordinators as soon as possible.

IX. Volunteers

Snowmobile clubs will be contacted by the Central Office through the media and their statewide telephone network after the decision to feed is made. Deer hunters in each group or club will be encouraged to take the lead and organize volunteer trips to northern regions to improve access and transport feed into the areas they hunt.

Areas and Regions are encouraged to continue planning meetings with local MDHA and other sportsmen's clubs. Each area must establish for itself its priority feeding sites and volunteer network. To ensure the best use of volunteers and feed distribution, we require that feed be distributed from depots on Fridays along with other times of your choice.

Areas and regions are also encouraged to find someone to volunteer their time to handle telephone calls from the public. Once this extensive feeding project starts, it is essentiall that field personnel time be devoted to making sure access is provided and that feed is properly distributed.

The "Need to Feed" leaflet will be completed soon and sent to areas. It can be given to volunteers.

Volunteers from the southern and metro areas will need a regional contact person who is not a Section of Wildlife staff person. Most wildlife staff time is expected to be consumed elsewhere. The regional I & E specialist is recommended. Regional Coordinators should work out these details with the Regional Administrators. Regardless of who is assigned by the Region, provide the name and telephone number to Rutske by Tuesday, February 21. Central office will prepare a news release for February 22 statewide release, that will notify volunteers of what work needs to be done, feed depot locations, and dates that feed will be available. A complete statewide list of feed depots will be forwarded to Regional Coordinators soon. A partial list is attached to the bid (See Appendix 9).

X. Feed

Southern Service Center sent bids to potential vendors on Friday, February 3. Bid opening is scheduled for February 16. Vendors were allowed to bid on 1, 2 or all 3 regions. The intention is to have 1 vendor assigned to each region. Vendors have 7 days after their bid is selected to begin shipments. Regional coordinators will be notified on February 17 of who was selected and who their vendor will be.

Regional Coordinators will be responsible for working with vendors and areas to schedule deliveries at each depot (Appendix 9). To request shipments, Regional Coordinators can order pellets by telephone and follow up order by a DPO to the vendor. Money to cover a DPO is not required until 30 days after the first invoice is received from the vendor. Therefore, we have about 30 days to supply you with additional funds after your first order is made.

Vendors are instructed to contact the Regional Coordinator only.

Shipments of 20 ton semi (truck loads) were requested. Bags will be on pallets so it may be helpful to borrow or rent fork lifts to unload the trucks.

Areas are responsible for verifying shipments, collecting shipping orders, and sending them to Regional Coordinators for payment. Funds to pay for the feed will be supplied to the regions when it is available. Regional coordinators should review the bids sent to potential vendors pertaining to the conditions of payments. They are responsible, along with the regional business manager, for making permit unless otherwise notified.

XI. Work Unit Description

This work unit should be used for the monitoring of our wintering wildlife populations, access development and improvement, the purchase and distribution of feed, and other associated activities.

Please note that this is a non-federal reimbursed unit.

Reference:	CC3	CC5 Loc Code	CC5 WU Code
	001	- - -	266

XII. Donations

A gift account has been established in St. Paul for donations to the deer emergency feeding. Donations will not be solicited until the decision to feed is made. Do not accept cash. Checks should be made out to the "Minnesota DNR - Deer Feeding". Donations to sportsmen's clubs or the Minnesota Deer Hunters Association Chapters who may have already started feeding or intend to do so should be encouraged.

Appendix 2. Description of Deer Management Units (DMU's)

Rainy River DMU

The Rainy River DMU represents the northwestern limit of the northern forest. Most of the land is poorly drained and lowland conifers predominate. Road access is poor and less than 6% of the land is under cultivation. Human populations are also very low. Spring deer population objectives range from 10 to 20 deer/mi.^{2}.

Superior DMU

The Superior DMU represents the northeastern limit of the northern forest. Road access is poor and less than .1% of the land is farmed. Human density is also low and concentrated along the North Shore of Lake Superior and near Ely. Spring deer population objectives range from 3 to 20 deer/mi.^{2}.

Itasca DMU

The Itasca DMU is the largest unit in the forest and is heavily forested with less than 5% of the land under cultivation. More than half of the land in this unit is owned by the public. Human densities are higher than the Superior and Rainy River Units and is concentrated along the iron range and in Duluth. Road densities are also higher than the previous two units. Spring deer population objectives in the Itasca DMU range from 10 to 20 deer/mi.^{2}.

Mille Lacs DMU

The Mille Lacs DMU begins the transition from forest to farmland. About 60% of the land is forested and 14% is under cultivation. This interspersion of forest and cropland creates excellent deer habitat. Over 70% of the land is privately owned and road access is higher than in the Itasca Unit. Spring deer population objectives range from 10 to 15 deer/mi.^{2}.

Agassiz DMU

The Agassiz DMU is characterized by flat land with a mixture of farm fields, woodlands, and wetlands. Over 85% of the land is privately owned. Spring deer population goals range from 5 to 6 deer/mi.^{2}.

Big Woods DMU

This unit is made up of rolling hills with more cropland than forest. About 95% of the land is privately owned. Much of this unit is receiving increasing human densities, especially those areas near the St. Cloud and Twin Cities metro areas. Spring deer population objectives are from 2 to 8 deer/mi.^{2} in this Unit.

Red River DMU

The Red River DMU in the northwestern portion of the state is generally flat to rolling with a predominance of cropland interspersed with small woodlands and wetlands. Over 98% of the land is privately owned. Human populations are low. Spring deer population objectives are 1 to 3 deer/mi.^{2}.

Prairie DMU

This unit includes most of the west-central and southwestern parts of the state although only the northern portion of this unit was included in the 1989 feeding program. Over 99% of this unit is privately owned and less than 6% of the land is in woodlands or wetlands. Spring deer population objectives in this unit are 1 to 3 deer/mi.^{2}.

Appendix 3.

Preprint - Will be published in Wildlife Society Bulletin, Spring 1991.

SIMULATION OF THE EFFECTS OF EMERGENCY WINTER FEEDING OF WHITE-TAILED DEER

Mark S. Lenarz, *Forest Wildlife Populations and Research Group, Minnesota Department of Natural Resources, 1201 E. Hwy. 2, Grand Rapids, MN 55744.*

The use of large scale emergency feeding to sustain deer populations has been controversial since its inception in the early 1930's. Most often the feeding programs were advocated by the public but relied on wildlife personnel to coordinate the programs. Early opposition argued that none of the supplemental foods available were effective at sustaining winter stressed deer (Carhart 1943, Doman and Rasmussen 1944, Erickson et al. 1961). More recent research (Ullrey 1971, Karns 1979, Baker and Hobbs 1985, Ozoga and Verme 1985), however, has demonstrated that it is possible to maintain deer on a nutritionally balanced ration. Despite this fact, the effect of supplemental feeding on the dynamics of a free ranging population has not been thoroughly evaluated.

In the following analysis, emergency feeding was defined as the distribution of supplemental food to deer populations during winters when deer are perceived to be stressed. As such, emergency feeding is treated as a management tool used to reduce starvation losses in late winter and in this context bears no relation to the year-long, *ad libitum* supplemental feeding carried on with many captive populations (eg. Ozoga and Verme 1982, Woolf and Harder 1979).

Emergency feeding has the potential to benefit deer populations in two ways. First, feeding can reduce winter mortality of winter-stressed deer (Baker and Hobbs 1985). Deer must survive on fat reserves accumulated the previous summer and fall (Mautz 1978) and supplemental feeding would slow the depletion of these reserves. Second, feeding can increase the survival of fawns born the following spring. Verme (1977) demonstrated that fetal growth is reduced in winter-stressed, pregnant does and suggested that subsequent survival of these under-sized fawns would be substantially reduced. Presumably, artificial feeding could maintain normal fetal growth and increase subsequent survival.

Much of the debate over artificial feeding revolves around the proportion of deer that can be fed, the impact on total population numbers, and cost. My objective was to simulate an emergency feeding program for white-tailed deer (*Odocoileus virginianus*) that projects the outcome of feeding and identifies how population parameters interact with the proportion of deer fed. The simulation results are then used to examine the cost effectiveness of emergency feeding.

METHODS

To simulate the effect of emergency feeding, I used a deterministic model similar to that described by Lenarz (1987) except that the simulation began with the post harvest period (mid-November) and ended with the pre-harvest period (early November) the following year (Table 1). Three sex and age classes were used (fawns, adult females and adult males). The fawns were exposed to two levels of winter mortality. First, normal winter mortality (NWM), which was defined as the level of mortality that was independent of winter severity and represented mortality associated with predation, poaching, accidents and disease. Second, high winter mortality (HWM), which included NWM plus the added mortality directly attributable to a severe winter. Adults were exposed only to NWM. Similarly fawns born the following spring were subjected to two levels of mortality: 1) normal summer mortality (NSM), and 2) high summer mortality (HSM). The latter attempts to simulate increased neonatal mortality following a severe winter (Verme 1977). The combination of HWM and HSM was intended to simulate a "worst case" scenario of mortality caused by a severe winter.

Table 1. Inputs and functions used in simulations.

Winter Mortality (Mid-November to May)		
Adult NWM	5.5%	Fuller 1990
Fawn NWM	11.0%	" "
Fawn HWM	40.0%	" "
Summer Mortality (June to early November)		
Adult NSM	8.5%	Fuller 1990
Fawn NSM	62.0%	" "
Fawn HSM	90.0%	see text
Normal Reproduction		
Fawns/Adult Female (NRA)	1.51	Fuller 1990
Fawns/Fawn Female (NFA)	0.09	" "

Pre-Fawning Population (PFP) = Post Harvest Population (PHP) Adults x NWM
+ PHP Fawns x % Fed x NWM
+ PHP Fawns x % Not Fed x HWM

New Fawns (NF) = PFP Adult Does x NRA + PFP Fawn Does x NRF

Post Harvest Population = PFP Adults and Short-Yearlings x NSM
+ NF x % Does Fed x NSM
+ NF x % Does Not Fed x HSM

The simulation assumed that a severe winter would result in HWM for all fawns and HSM for all fawns born the following spring. The mortality rate of fed fawns was lowered from HWM to NWM to simulate the effects of emergency feeding. This means that the survival of fed deer was independent of winter severity but that they were still subject to normal mortality from predation, poaching, accidents and disease. The survival of fawns produced by fed deer was raised from HSM to NSM to simulate increased neonate survival. Thus, feeding was an all-or-none phenomenon; that is, no matter how much food a deer ate, its survival (and that of it's offspring) was increased dramatically. In addition, the sex and age classes of deer that ate the feed were proportional to these classes in the population.

Simulations were of the deer population in a 6991 km2 deer management subunit (Itasca NE) in northeastern Minnesota. Density and sex and age ratios from previous harvest management simulations (M.S. Lenarz, Minn. Dep. Nat. Resour. [MDNR], unpubl. report) were used for the initial population. All mortality rates except HSM (Table 1) were based on a telemetry study on deer in and adjacent to Itasca NE (Fuller 1990). HSM was arbitrarily set at 90% to include 70% neonate mortality (Verme 1977) plus an additional 20% post natal mortality. The reproductive rates (fetuses/doe; Table 1) used in the simulation were also taken from Fuller (1990) and based on car killed deer in northcentral Minnesota (P.D. Karns, MDNR, unpubl. data). The starting post-harvest population contained 4.9 deer/km2 including 24% adult males, 52% adult females, and 24% fawns.

A series of simulations was run to determine the effect of feeding. In each series, the proportion fed ranged from 0 to 30% in 5% intervals. For benchmark purposes, it was assumed that 10% of the population was fed. Sensitivity analyses were also conducted to determine how changes in reproductive rate and fawn mortality rates effected model results.

Two response variables were calculated to identify the effects of feeding. First, deer saved (DS) is the difference in numbers between a fed population and an unfed population following winter mortality (at pre-fawning) divided by the pre- fawning unfed population. This represents the proportion of the pre-fawning deer population saved by feeding. Second, deer available (DA) is similar except that the numerator is the difference following summer mortality (at pre-harvest) and includes DS plus the fawns saved by the increased neonatal survival of fed deer. As such, DA represents the increase in deer numbers available for harvest compared to the number if feeding had not taken place.

RESULTS

In this emergency feeding program, both DS and DA are a function of the proportion of deer fed (Fig. 2). Under benchmark conditions, the pre-fawning population would be only 0.8% larger than if no feeding had taken place. Even if 30% of the deer were fed, the pre-fawning population would be 2.4% larger. At benchmark conditions, the pre-harvest population would be only 3.1% larger than if no feeding had taken place. This proportion, DA, includes both deer saved in the previous winter as well as the improved survival of neonate fawns. Unless a large proportion of the winter stressed deer are reached by such a program, however, the proportion of deer actually saved, is relatively small.

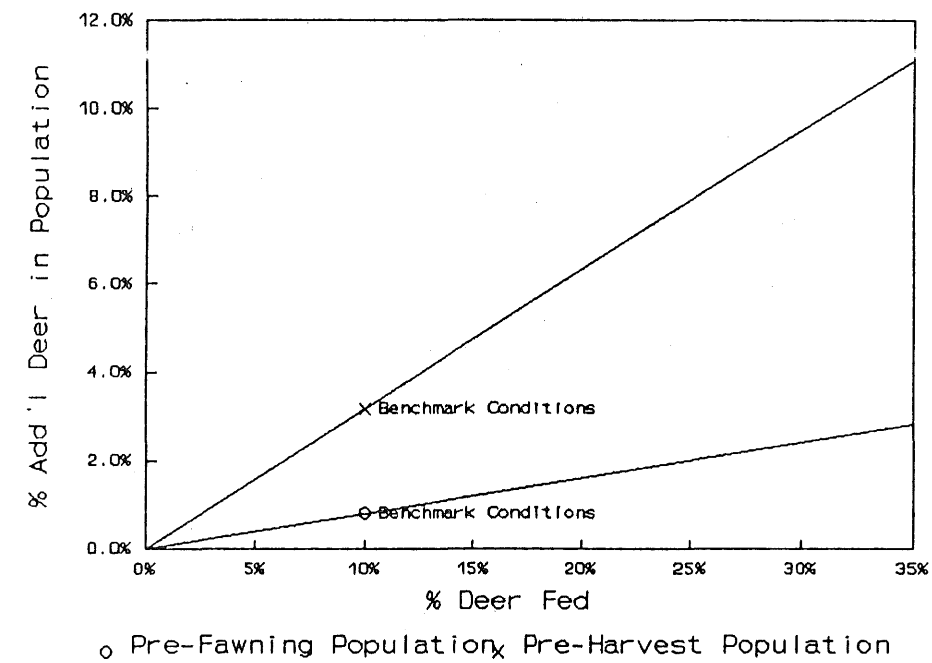

Fig. 1. Relationship between % deer fed and % additional deer in the pre-fawning and pre-harvest populations. Both are independent of starting density.

In the Itasca NE subunit, at benchmark conditions, the pre-harvest population would contain 0.02 additional bucks/km^2 or a total of 0.13 additional deer/km^2 than if no feeding had taken place. Both DS and DA were independent of the starting density and if the starting population is doubled, the number of additional deer saved/km^2 is doubled. Thus, even with a starting population of 9.8 deer/km^2, a total of only 0.27 additional deer/km^2 would be added to the population at benchmark conditions.

Analyses indicate that DA is relatively insensitive to changes in the reproductive rate (Fig. 3). At benchmark conditions and with 1.3 fawns/doe, DA is 2.8%; at 1.7 fawns/doe, DA is 3.5%, a difference of only 0.7%. While reproductive rate is an important parameter in the model, it has little effect on DA because of the high levels of fawn mortality used in the simulations. Similarly, DA is relatively insensitive to the difference between NWM and HWM in fawns (Fig. 4). When HWM is 2 times NWM and with 10% feeding, DA is 2.5%; when the HWM/NWM ratio increases to 8, DA increases to 5.0% an increase of 2.5%.

DISCUSSION

Severe winter weather has been accepted as the cause of large losses in northern deer populations (Dahlberg and Guettinger 1956, Erickson et al 1961.). There are very few studies, however, that document winter mortality levels or the variability in winter mortality as a function of winter severity. Nelson and Mech (1986a) determined sex and age specific mortality rates of radio-collared deer in northeastern Minnesota but did

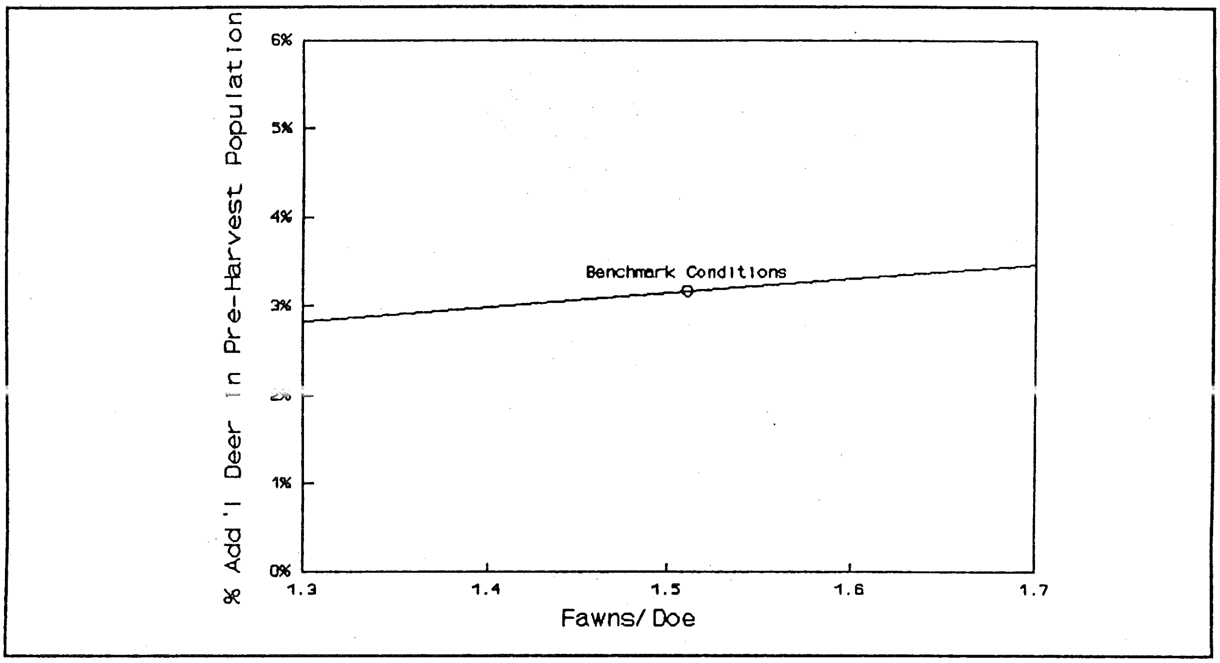

Fig. 2. Relationship between % deer fed and % additional deer in pre-harvest populations. At benchmark conditions, 91% does (≥2 years) are pregnant with 1.66 fawns/pregnant doe.

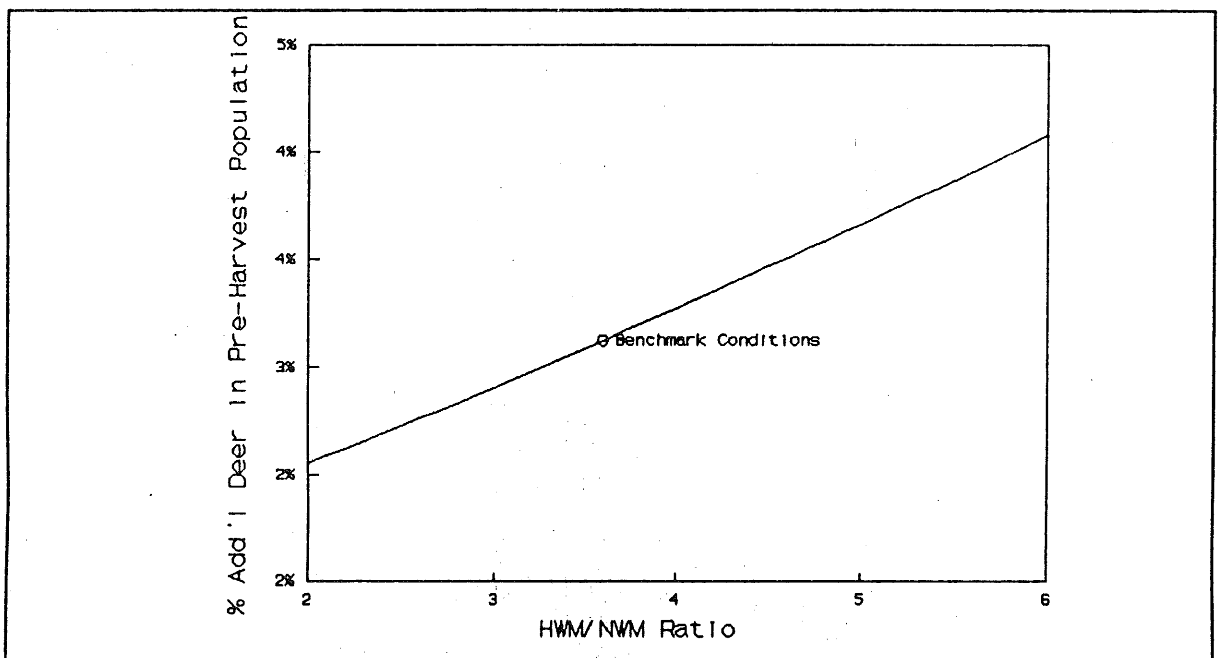

Fig. 3. Relationship between the relative magnitude of mortality during a severe winter and % additional deer in pre-harvest population. With a ratio of 2, fawn mortality during a severe winter is 2 times higher than in a "normal" winter.

not segregate mortality according to winter severity. There was, however, a significant positive relationship between snow depth and wolf (*Canis lupus*) predation rate (the primary source of mortality) of adult and yearling deer (Nelson and Mech 1986b). In more recent analyses (Nelson, pers. com.), fawn mortality was almost twice as high during winters with a snow index >30 (see Nelson and Mech 1986b for snow index) than in years with a lower index. A study of radio-collared deer in northcental Minnesota (Fuller, 1990) found no significant difference in mortality rates of adult deer between winters with shallow or moderate snow (mean weekly snow depth December-March, 13-16cm vs 36-44). Fawn mortality differed significantly ($P=0.003$); December to May mortality was 11% for shallow snow and 40% for moderate snow.

There is even less quantitative information available on the effect of winter severity on neonate survival. Verme (1962, 1963) found that the nutritional plane of a doe, especially late in her pregnancy, greatly influences the growth of her fetus. Based on this inference, Verme (1977) used growth curves to predict birth weight of under-nourished fetuses and their probability of survival. He estimated that following mild winters, neonate morality averaged 10% but that following severe winters neonate mortality ranged from 50 to 68%. It should be noted that these rates represent losses to malnutrition and do not include other normal sources of mortality such as predation, poaching, disease and accidents.

The proportion of deer fed was the most sensitive parameter in the model and is probably the most difficult to determine in the field. Ozoga and Verme (1985) found that supplementally-fed deer consumed a mean of 1.3 kg/day between 1 December and 15 April. An estimated 290 metric ton of feed was distributed to deer in Itasca NE between 1 March and 15 April 1989. At 59.8 kg/deer (1.3kg/day/deer x 46 days), a maximum of 4857 deer could be fed which is 12% of the post-harvest population. Because this unrealistically assumes that none of the feed was wasted, the actual proportion of deer fed is, at best, similar to the 10% used as a benchmark value.

The cost effectiveness of a feeding program is dependent on the value applied to the deer that are saved. Daniels and Riggs (1988) recommended that the most acceptable way to measure the value of deer is with a willingness-to-pay value derived from hunter demand functions. Based on their recommendation, Lenarz (1988) estimated a value of \$472/deer harvested in Minnesota. This figure represents the willingness-to-pay value for any deer and it is reasonable to suggest that this value would be higher for bucks. For the following calculations, the willingness-to-pay value for buck was arbitrarily increased by 25% to \$590.

At benchmark conditions, a total of 908 additional deer (0.13 deer/km^2 x 6991 km^2) would be available for harvest. In Minnesota, however, deer hunting is limited to bucks-only hunting with a limited number of antlerless permits. Most likely, fewer antlerless permits would be allocated following a severe winter and thus it is unlikely that the antlerless harvest would increase as a result of feeding. The simulations indicated that 140 additional adult bucks (.02 bucks/km^2 x 6172 km^2) would be available following a feeding program. Since 1982, the buck harvest has averaged 26% of the estimated pre-harvest adult buck population (range 23-30%). Even if we assume that 30% of these additional deer would be harvested, the buck harvest would increase by only 42 bucks. Thus, for artificial feeding to be cost effective in this subunit, a maximum of \$24,780 could be spent (42 bucks x \$590/buck harvested; Fig. 5). It is important to note, however, that this assumes that 10% of the deer are fed. If only 5% of the deer were fed, a maximum of \$9,558 could be spent and if 30% were fed, \$57,348 could be spent. It is also important to remember that these costs include the feed as well as the logistical costs associated with its distribution.

In 1989, the cost of deer feed for Itasca NE was \$191/metric ton and a total of \$55,390 was spent just for the purchase of food. While this figure does not include the logistical costs of distribution, it is clear that emergency feeding was not cost effective management under benchmark conditions. Emergency feeding only begins to approach cost effectiveness if the willingness-to-pay value for a harvested buck is substantially higher (\$1318). If a larger proportion of deer could be fed, the cost of feed would be proportionately higher and emergency feeding would still not be cost effective (Fig. 5). Even if HWM was 8 times NWM and 88% of the fawns were lost during the winter, feeding would still not be cost effective (Fig. 6). Therefore, based on economics it is difficult to justify the use of emergency winter feeding as a management tool in northeastern Minnesota.

SUMMARY

An emergency feeding program for white-tailed deer was simulated that assumed that (1) deer with access to feed suffered normal levels of mortality, and (2) deer without access suffered much higher levels of mortality. The model was used to simulate the numbers and proportion of deer saved from over-winter mortality as well the additional fawns saved with increased neonate survival.

The proportions deer saved (DS) and deer available (DA) in the simulated feeding program were positive linear functions of the proportion fed. Both DS and DA were independent of the starting density. In the subunit modelled, only 0.13 additional deer/km^2 were available prior to the subsequent hunting season.

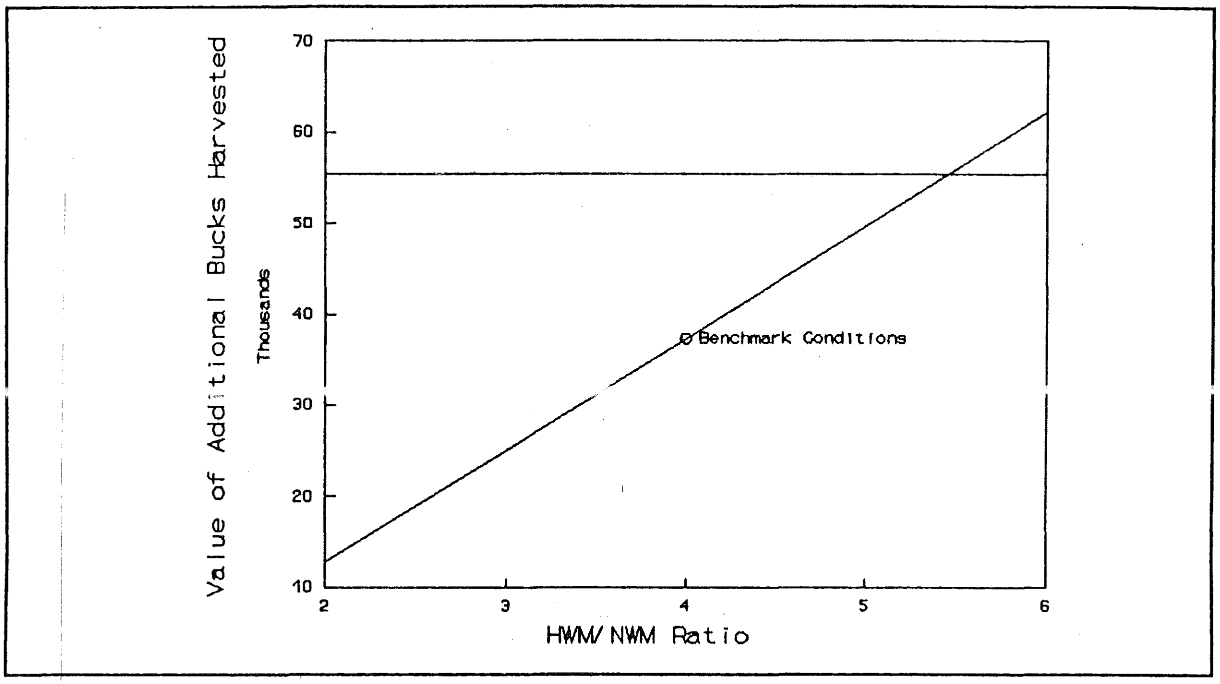

Fig. 4. Relationship between % deer fed, feed costs, and the value of additional bucks harvested. Cost of feeding assumes that each deer will require 59.8 kg feed between 1 March and 15 April, feed costs $191/metric tone, and a post harvest (pre-feeding) density of 4.9 deer/km^2. The relationship is independent of density.

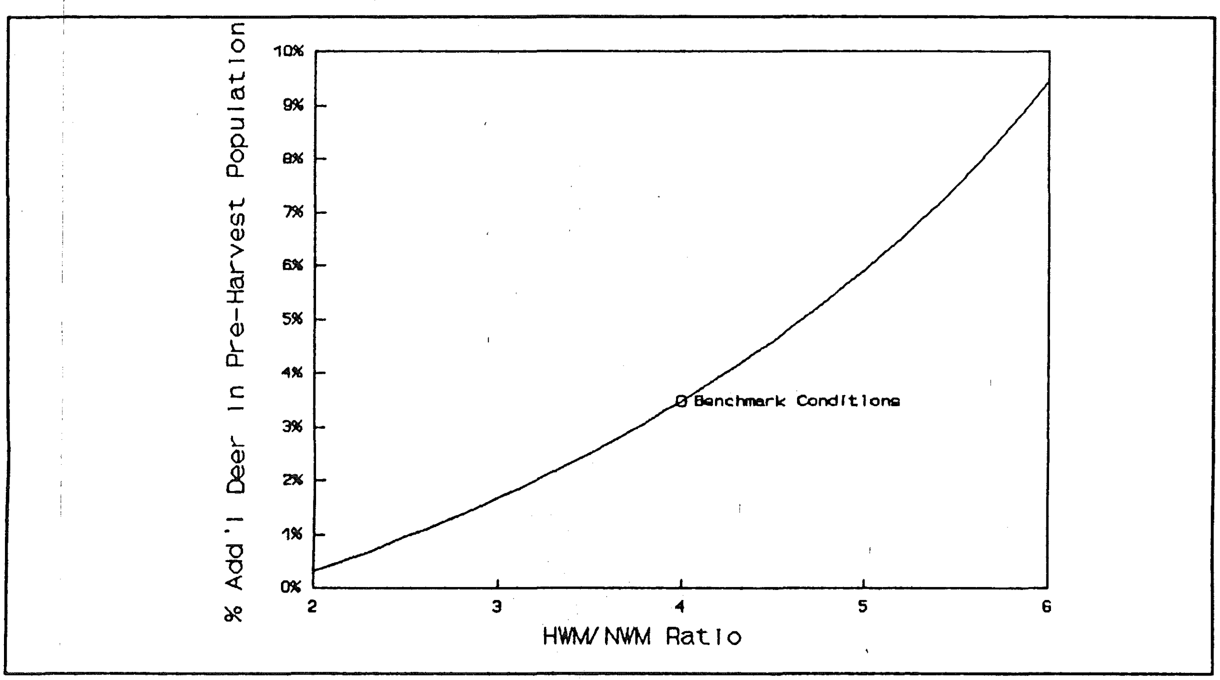

Fig. 6. Relationships between the relative magnitude of fawn mortality during a severe winter and the value of additional bucks harvested. Cost of feeding includes feed only, not logistical support.

The simulations were relatively insensitive to changes in reproductive rate or the magnitude of mortality associated with a severe winter. Based on the simulations, the emergency feeding program for Itasca NE was not cost effective. Even with simulated 88% fawn winter mortality, it was not cost effective to feed deer.

Emergency feeding only begins to approach cost effectiveness if the value of harvested bucks is considerably higher than used in the comparisons.

Acknowledgements: I thank T.K. Fuller, W.E. Berg, M.E. Nelson, K. McCaffery, R. Lake, T. Bremicker, L. Verme and an anonymous referee for their comments and helpful criticisms.

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