When All the Clean Water Is Gone

A Teacher's Guide

Minnesota Department
of Natural Resources
Rivers Section
July 1981

Dear Instructor:

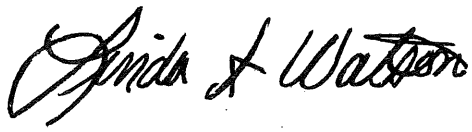
When All the Clean Water Is Gone was written to make students aware of the water resource problems we face today, of their role in creating or aggravating these problems, and of what they can do to help correct them.

The comic book is intended for grades five through eight, but may be suitable for other grade levels as well.

This teacher's guide presents a series of concepts, background discussions for your use and a number of discussion questions and activity suggestions. It may be used as a complete study unit or in conjunction with an established natural science curriculum. The amount of time that is spent on it and the use that is made of it are, of course, up to you.

We would like to hear about your classroom experience with the comic book and guide. Please take a few minutes to fill out and return the enclosed questionnaire. Thank you.

Sincerely,



Linda Watson
Editor, Rivers Section
Department of Natural Resources

When All the Clean Water Is Gone

We would like to hear about your classroom experience with the comic book and guide. Please take a few minutes to fill out and return this questionnaire. Please return to: Minnesota Department of Natural Resources, Rivers Section, Box 10G Centennial Building, St. Paul, MN 55155.

School:

Grade Level:

Number of students:

Use of comic book (complete unit, part of established curriculum, etc.):

Time spent on comic book:

Your opinion of comic book:

Your opinion of concepts:

Your opinion of background discussions:

Your opinion of questions and activities:

Your students' reaction to comic book:

Your students' reaction to questions and activities:

Suggestions for improvement?

Additional comments:

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July-August 1979

Changing Role For Our Rivers

Minnesota's rivers, once lifelines of immigration and commerce, today harbor values in danger of being lost.

LINDA WATSON

Throughout history people have depended upon rivers for their livelihood. More than a source of fresh water and food, rivers gave to developing societies their movement.

Endlessly moving, rivers carried and deposited rich sediments, forming floodplains and deltas. These fertile soils enabled agricultural civilizations to flourish.

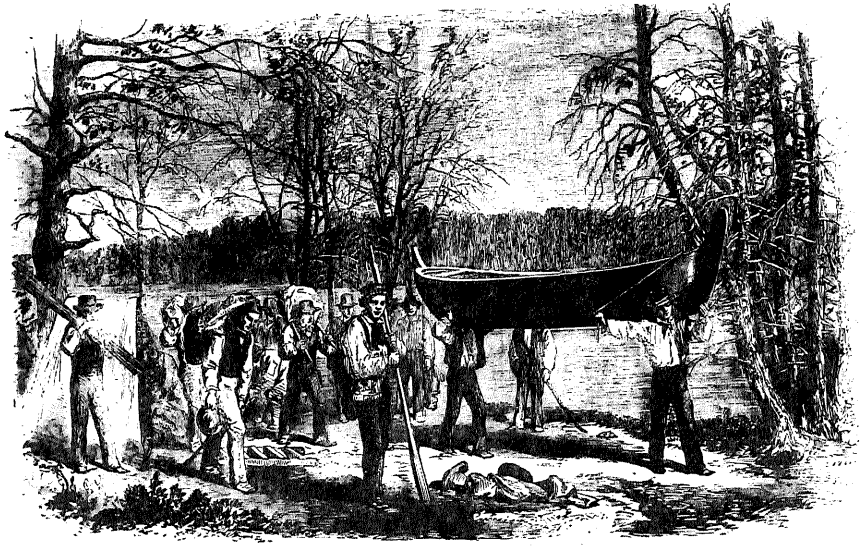
That rivers could carry not only sediment, but people and goods as well, was tremendously important to commerce during a time when overland travel was arduous.

Rivers often sliced through otherwise impassable natural barriers such as mountain ranges; for centuries these water avenues were vital not only to commerce but to the exploration and settlement of new lands.

The thousands of miles of rivers and streams that web Minnesota not only aided exploration, but were themselves often the objects of exploration. Rumors of a mighty river that led south to the wealth of the Indies, of a riverine northwest passage that led to the Pacific, and a gateway to the riches of the Orient, kept French, British, and American explorers occupied for more than a century.

In the New World, as in the Old, rivers were recognized as a valuable economic resource. The first white commerce in Minnesota depended on rivers. The fur trade began soon after initial French and British explorations revealed an abundance of

~~Runabout on the Mississippi River near Winona~~



This 1858 illustration from the "London News" depicts a portage on canoe route between Grand Portage, Fort Francis, and Fort Garry.

fur-bearing animals and Indian tribes willing to supply pelts. The success of this venture depended on the fur companies' ability to bring trade goods into, and ship furs out of, an unbroken, trackless wilderness. Rivers were invaluable.

Voyageur's Highway. Using the vast network of waterways canoed for centuries by the Indians, the fur traders were able to travel from Lake Superior throughout northern Minnesota and south to the Mississippi River watershed.

The St. Louis River, which empties into Lake Superior near Duluth, was a vital link in this network. Canoe brigades, laden with supplies and trade goods for posts on the upper Mississippi, ascended the St. Louis to the first obstacle, the rapids-filled gorge now in Jay Cooke State Park. The three-day, seven-mile haul around these rapids became known as the St. Louis River Grand Portage. The upper end of the portage was at Maple Island, a mile below present-day Scanlon. From here the voyageurs paddled to Knife Falls (Cloquet), where they faced the mile-long Knife Portage.

A distance above Knife Falls was the St. Louis River Grand Rapids, a difficult stretch of water. Most canoe parties did little portaging, but it was a real test for the voyageurs, who often had to jump into the river and drag their canoes through the rough reaches.

At Floodwood the traders paddled up the slow, meandering East Savanna River to the limit of navigation, then dragged canoes and loads through a crude canal that saved a mile of portaging.

At the west end of the canal was the Savanna Portage, a grueling trek through a tamarack swamp. This portage was widely-known as one of the most formidable in the region because of its length, mud, and mosquitoes. Toting heavy packs, the traders balanced on poles laid lengthwise through the mire. From the west end of the portage it was possible to descend the West Savanna River into the Prairie River, then into Big Sandy Lake, and finally into the Mississippi.

Another northern water trade route, the Old Vermilion Trail, linked Lake Superior with Vermilion Lake and points north. Traders canoed almost 100 miles up the St. Louis, then ascended the Embarrass River and paddled and portaged through several lakes. A descent on the Pike River brought them to trading posts on Vermilion Lake, a starting point for waterways leading to the Canadian wilderness.

To the south, the trade routes fed more directly into the Mississippi. Posts were scattered along the Cannon, Minnesota, Rum, and Crow Wing rivers and their tributaries. Trade goods — blankets, guns, knives, mirrors, tobacco, and cloth — were sent upriver from St. Louis soon after the Mississippi opened and were stored in the American Fur Company warehouse at Mendota. Traders journeyed to Mendota in the spring, packing the furs they had collected during the winter.

Wooden Cargo. In 1837, the Ojibway Indians ceded to the United States the wedge of land between the Mississippi River and the upper St. Croix, heralding a new era of large-scale river use in Minnesota. For the next century, the chief cargo of central and northern Minnesota rivers was logs. The harvest of Minnesota forests would have been impossible without our waterways. Rivers carried logs downstream to mills which were themselves powered by the water's current.

Logging began in the vast forests of white pine that flanked the St. Croix and its tributaries. In 1839 the first sawmill on the St. Croix was put into operation at Marine; Stillwater followed five years later. At St. Croix Boomsite Park, a series of long, narrow islands in the St. Croix north of Stillwater, millions of logs were sorted before continuing their float trip to mills downstream.

Pine was plentiful in these early logging days, but food was scarce and expensive. Wild game and garden produce could not begin to meet the needs of the few thousand settlers living in St. Paul, St. Anthony, and the St. Croix valley during the 1840s. Again rivers provided a solution. Steamboats carried huge

cargoes of provisions up the Mississippi from St. Louis to docks at St. Paul and Mendota.

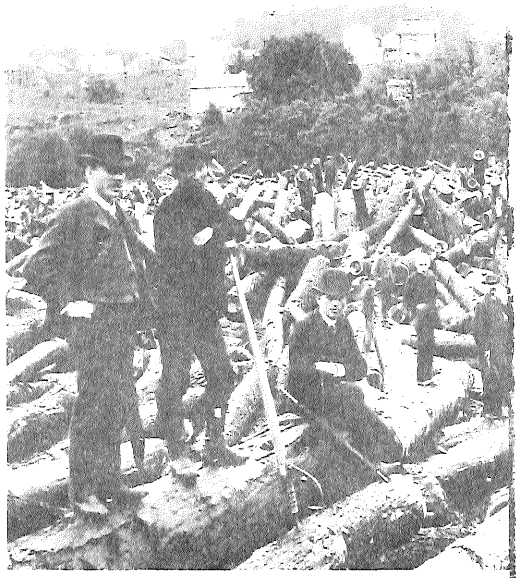
Along one of the St. Croix's tributaries in east-central Minnesota, the booming lumber industry helped sustain a healthy resort and excursion business. Logging dams on the Snake River and its tributaries held back an immense volume of water for spring log drives. When the water was released, it flowed to Cross Lake where it was impounded and backed up for miles. The resulting depth could float a shallow-draft steamer.

Elijah Seavey, formerly a pilot on the Mississippi and St. Croix rivers, captained the "Kate R" on the Snake for many years. During the week the sternwheeler carried freight. On the weekends it did a brisk excursion business, carrying passengers from Pine City to resorts on Pokegama Lake.

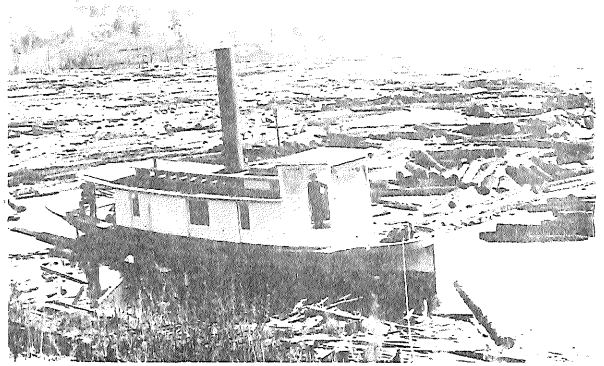
The dams were dismantled when the timber industry moved to northern forests around the turn of the century. Without sufficient water for steamer traffic on the Snake, the resort industry declined.

The loggers moved west and north as new lands were opened to settlement and the eastern pine stands were exhausted. The last frontier for the logging industry in the state was along northern Minnesota rivers such as the Cloquet, St. Louis, Big Fork, Little Fork, and Vermilion.

Timber floated down these rivers was shipped to the eastern United States and beyond. New York and Chicago were important customers; as the oil and steel industries grew, cities such as Pittsburgh and Cleveland demanded lumber. Minnesota pine even found its way to the West Indies, where it was used for sugar and molasses barrels.



Left: Townsfolk inspect a massive log jam at Taylors Falls on the St. Croix River in 1884. Below: Northern Mill Company's boat on the St. Croix, about 1900.



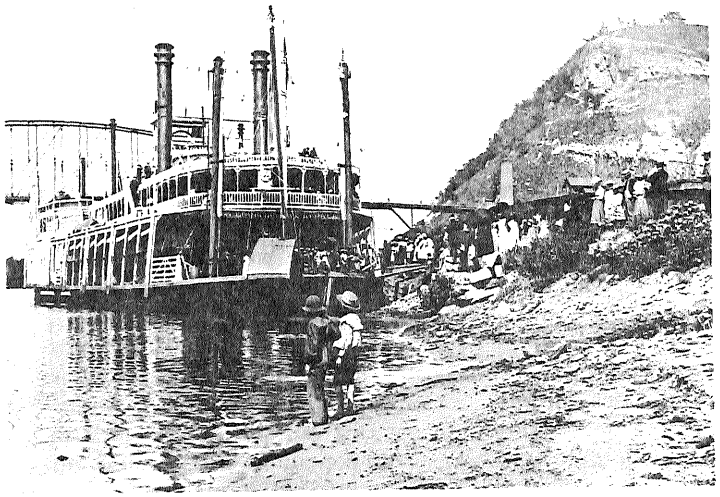
In southern Minnesota the logging industry never reached such proportions. Sawmills prospered for a time along the Cannon River as the Big Woods, an extensive hardwood forest, was logged. But the harvest greatly exceeded the annual growth, rapidly diminishing the timber supply.

Millstream. The removal of the Big Woods opened land to cultivation, and southern rivers were adapted to another use. Sawmills were converted to grist mills as the Cannon River valley became one of the most important wheat areas in the country. By 1877, 15 flour mills flanked the Cannon between Faribault and Northfield. In 1880, flour produced in Cannon River mills commanded the highest prices on the New York and London exchanges.

At Dundas, visitors can see the aging limestone walls of the Archibald Mill. One of the largest mills on the Cannon, it occupied a three-story building and powered four pairs of millstones. Farmers from as far as 80 miles away used the Archibald mill.

To most people of the 19th century the swift waters of the Cannon River meant industrial power. But at least one man thought of large-scale transportation. Ignatius Donnelly, a Minnesota Congressman in the 1860s, dreamt of developing a steamboat route from the Minnesota River to the Mississippi via the Cannon and a series of locks. This route had been used for hundreds of years by Indians traveling in canoes, but was not destined to be adapted for modern transportation.

The Minnesota River was itself a steamboat route, a highway to the fertile western prairie. By 1853 eight steam paddlewheelers plied the river, bringing passengers and goods to the growing towns and cities on its



1898 photo of steamboat "Quincy" landing at Red Wing harbor on the Mississippi River.

banks. For 20 years, until the completion of the railway, steamboats were the primary means of transportation in the river valley.

A network of railroads and highways took the burden of transportation off most Minnesota rivers, but population, cities, and industries continued to grow. In Minnesota cities, river areas have often become unsightly industrial districts, unfit for fishing or swimming, offensive to both nose and eye. Proliferation of housing developments on suburban and rural riverfront property has destroyed irreplaceable agricultural land and wildlife habitat, and created erosion-scarred riverbanks.

Some Minnesota rivers have fared better than others. Accidents of nature have helped to preserve the upper St. Croix's natural beauty. Sandy soil unfit for farming and rapids that made transportation impossible discouraged 19th century immigrants from settling the river valley above Taylors Falls. So, too, in parts of northern Minnesota, areas unfit for farming, mining, or industry have been thus accidentally preserved — so far.

New Values. In 1969, through the Shoreland Management Act, the Minnesota legislature acknowledged that the state's public waters need protection. However, as the "land of 10,000 lakes," the state was naturally biased toward those water bodies; rivers received only minimal protection. Not until 1973 did Minnesota realize it had a further obligation toward its outstanding rivers.

With passage of the Wild and Scenic Rivers Act, the legislature recognized the necessity of a statewide system to preserve and protect exceptional rivers — a statewide system that would ensure a consistent, minimum level of protection for rivers that flow through many different government jurisdictions.

The Wild and Scenic Rivers Program is not meant to turn back the clock to the fur trading days, nor could it. Rather, it is meant to stop the degradation of riverside land that accompanies intensive development, poorly-planned zoning, and recreational overuse.

The rivers program can accomplish this goal in three ways: through zoning for low-density riverside development; through the purchase of "scenic easements" on natural river land; and through river recreation management.

Larger lot sizes, building and septic system setbacks, and regulations that govern cutting of riverbank vegetation produce many benefits for a river and for those who live along it. These zoning provisions help prevent overcrowding of homes along the river, thereby reducing the number of roads, clearing of vegetation, and installation of septic tank systems. They also help to minimize erosion and maintain a screen of vegetation that provides wildlife habitat and keeps structures from dominating the landscape.

Through scenic easements the DNR can pay landowners to leave parts of their riverside property in a natural condition. Terms of an easement are negotiated between the DNR and the landowner and may include promises not to build, to cut timber, to dump trash, or to grade, fill, or drain property. The easement remains in effect permanently and runs with the title to the land. Scenic easements are purchased only from **willing sellers** and do not open land to public use.

Through recreation management, the Wild and Scenic Rivers Program provides enough public recreation sites to accommodate existing river use. The program does not promote river use; in fact, it imposes stricter trespass regulations.

Today, five river stretches in Minnesota are in the Wild and Scenic Rivers System: the Kettle in Pine County, the Mississippi from St. Cloud to Anoka, the North Fork of the Crow in Meeker County, the Minnesota from Lac qui Parle to Franklin, and the Rum from Lake Ogechie to Anoka.

Many more outstanding Minnesota rivers need the protection the Wild and Scenic Rivers Program can provide. These rivers are part of a natural heritage that we lose each time politics speak louder than a rushing river, each time money appears brighter than sunlight on water, each time "progress" precludes preservation. □

Linda Watson is publications editor for the Wild and Scenic Rivers Program, Rivers Section, DNR.

Contents

Comic book, inside front cover

Concept: Rivers have changed as a result of the development of modern society.

The article, "Changing Role for Our Rivers," can be used as a basis for discussion of the history and use of rivers in Minnesota. To summarize, rivers were first used by Indians and prehistoric peoples for food, water and transportation. Fur traders relied on our extensive river network to transport furs and supplies in the 18th and early 19th centuries. The timber industry, arriving in the mid-19th century, used rivers to transport logs to water-powered sawmills. Settlers established communities along rivers to take advantage of their water, water power, and transportation uses. A network of railroads and highways took the burden of transportation off most Minnesota rivers, but population, cities and industries continued to grow. In Minnesota cities, river areas have often become unsightly industrial districts, offensive to both nose and eye, and sources of serious water pollution problems. Proliferation of housing developments on suburban and rural riverfront property has destroyed irreplaceable agricultural land and wildlife habitat, and created erosion-scarred riverbanks.

Discussion questions:

1. The inside front cover of the comic book shows a young girl playing on the banks of a polluted river in a big city. Her grandmother is remembering how the river used to be, perhaps when she played on its banks as a child.

   How has the river in the picture changed?

   --The trees and grass are gone, replaced by buildings and bare, eroding banks. The deer are gone; at least some of the fish are dead and the rest may be inedible. The water looks dirty, and has trash and pollution floating on it and flowing into it. The air is filled with smoke from factories.

2. The deer were drinking from the river. Could the water be drunk now?

3. How does the grandmother feel about the change in the river?
   Why? Solicit opinions.

   --She looks sad, perhaps because of the way the river has changed, perhaps because her granddaughter will never know the river as she did.

4. How does the girl feel about the changes? Why? Solicit opinions.

   --The girl is too young to be aware of the change; the river as it is now is the one she grew up with.

5. Is this a good place for children to play? Why or why not?

6. Is the river prettier or uglier now? Why? What does beauty contribute to our lives?

7. Using "Changing Role for Our Rivers" as a basis for discussion, discuss the ways in which people have used rivers in general (--to make their life or work easier), and the ways rivers have been used in Minnesota.

8. By what group of people or during which time period has the river been changed the most? Indians? Fur trappers? Loggers? Farmer-settlers? Modern cities and industry? Discuss the extent of change in each period.

9. What do you think the pictured river was used for when the grandmother was young? What is it used for now?

10. What do you suppose could have been the stages in the pictured river's development from deer to big city?

11. Is the river important to us now? Why? Will it be important to future residents?

12. What do you think the river will look like in the future?

13. What changes do you think could be made to make the river look and smell better?

14. Who does this river belong to?

    --In Minnesota, navigable rivers are considered public waterways; that is, the river (not the banks) belong to everyone--anyone can use it.

15. Should anyone be allowed to destroy the use someone else might make of the river? --e.g., industrial waste discharge vs. swimming or fishing

16. How are the people who live downstream of this city affected by the pollution?

--The point should be made that much of the pollution entering the river will flow downstream and affect the next community along the river, just as the communities upstream of this city send their pollution downstream. In fact, the only really clean water left may be in river headwaters areas that are not near human activity.

17. Do the communities along the river have the right (moral, not legal) to send polluted water to the communities downstream of them? How dirty will the water be when it reaches the ocean?

Activities:

1. Have the students draw the possible stages in the pictured river's development from deer to big city.

2. Have the students draw the way they think the river will look in the future. When the drawings are completed, discuss why they think it will look that way.

3. Check with your local historical society for photos or paintings of early river scenes. Compare with modern photos and discuss.

4. Find out about the history of a nearby river. Visit it if possible and discuss the changes as they may have occurred at the site you visit.

5. Divide into two or more groups. Two types of poems will be written, one about the river before development and one about the river after development (or one for each historical period--Indians, fur traders, loggers, etc.). Each student states a different word to describe the river of that period. Use these words as the principal words in a poem about the river.

Comic book, p. 1

Concept: Water pollution is a growing problem that affects all of us.

Water pollution means waters are adversely affected for domestic, industrial, agricultural, wildlife or recreational uses. Whether a lake or river is considered polluted depends on its actual or potential uses. To be suitable for municipal water supply and for recreational uses such as swimming and fishing, the water must be reasonably free from health-endangering chemicals and bacteria, as well as objectionable tastes and odors. Industrial water supply needs vary widely among industries; usually the water must not contain damaging concentrations of corrosive chemicals or deposit- or slime-forming chemicals.

Pollution of the state's rivers and lakes comes from many sources. Most obvious are the "point" sources of pollution -- direct wastewater discharges through a pipe, conduit, ditch, etc., from places such as municipal wastewater treatment facilities and industries. Raw or inadequately treated sewage still flows into streams and every year communities outgrow their sewage treatment facilities. The wastes from municipal and industrial sources inhibit water recreation, increase the cost of water treatment, impair the survival of both game and commerical fish, damage aesthetic values and corrode structures exposed to water.

Even if all industrial and municipal point sources of pollution were brought into compliance with state Pollution Control Agency standards, "non-point" sources of pollution would continue to be a problem. Non-point pollution sources are usually spread over an area, such as pesticides, nutrients and soils washed from farm fields, and the debris, oil and chemicals carried from city streets by stormwater runoff. Other significant types of non-point sources of pollution which affect water quality in Minnesota include forestry, mining, construction activities, dredging and some recreational activities (40 percent of the gasoline fumes and residue from power boats end up in the water).

Discussion questions:

1. What can you do in a clean lake or river that you can't do in a polluted lake or river?
   --fish, swim, water ski, other water contact activities

2. How can you tell a river or lake is polluted?

   --some indicators: dead fish, oil skim, algae and foam, odor, trash

3. How does water pollution affect us as a country, state, county, city, individual?

   --shortage of clean water, loss of tourist dollars in water recreation areas, loss of water recreation opportunities, increased cost of water purification, etc.

4. Why does the water pollution problem continue to grow?

   --continued growth of population, construction, industry, use of chemicals in agriculture

5. What are some sources of point and non-point pollution in your neighborhood or community?

6. How does an average household waste water or contribute to water pollution?

   --using more water than necessary for baths, showers, flushing the toilet, washing clothes; leaving the water run when washing dishes, brushing teeth or waiting for a cold drink (keep a bottle of cold water in the refrigerator); washing grease or coffee grounds down the kitchen sink; using chemical fertilizers, pesticides and herbicides in the yard (runoff after rainstorms eventually enters the water supply)

7. Are you willing to change water-wasteful or water-polluting activities in your household?

Activities:

1. Have the students go out and collect what they think is dirty water. Have them bring the samples back into the classroom and observe the water. What types of pollution can they find in the samples? What about the water makes it dirty? Now tell them that their job is to clean the water using funnels, cloth, filter paper, etc. Have them try to clean the samples. What things could they clean up or filter out? What types of things couldn't they clean up (smell, color, etc.). Discuss the difficulty of cleaning water. A good follow-up to this activity would be a visit to the local water treatment or sewage treatment plant.

2. Visit a water treatment or sewage treatment plant to find out what is involved in cleaning water. Ask about costs to the taxpayer and how much they have increased over the past 10 years. Is the plant in need of expansion or has it been expanded in the past 10 years? Find out why.

3. Visit a nearby lake or river. Try to spot and list sources of point and non-point pollution. Do the same on the schoolgrounds, in your neighborhood. What do you think can or should be done about these problems?

4. Have the students find pictures in magazines of water pollution. Have the students make a display of these pictures on a bulletin board in the classroom. Discuss several of the pictures and ask the questions: "How does it affect you?" "What can you do to help solve the problem?" "How do these photographs make you feel?"

Comic book, pp. 2-3

Concept: Anything that contaminates a link in the aquatic food chain can eventually affect us and all the other living things in the ecosystem.

A food chain is the transfer of food energy from one living thing to another. A food chain always begins with plants, which, through photosynthesis, make the energy of the sun available to the plant eaters. The plant eaters in turn are consumed by meat eaters. All of the links in the food chain--the plants, the plant eaters and the meat eaters--depend on water. If the water is contaminated, the contamination can be passed from one link in the food chain to another. Since we humans are the final link of many food chains, the contamination can affect us as well.

The case of the insecticide DDT illustrates the widespread contamination that can result when a toxic element is introduced into the world's complex web of interrelated food chains.

DDT was first introduced in 1942. It was used to kill malaria-spreading mosquitoes, and helped to virtually eliminate malaria in the United States by 1951. Since mosquitoes breed in an aquatic environment, the DDT entered the water and thus the food web.

In the early 1950s scientists noticed a population decline in several species of birds, including eagles, ospreys and peregrine falcons, which seemed to be producing fewer young. Several years later, the connection to DDT was established. The birds pick up the pesticide from fish and other animals on which they feed. DDT upsets the balance of hormones in the female bird that are necessary to the production of calcium for sturdy eggshells. The bird continues to lay eggs, but the shells are too thin to protect the embryos inside.

The peregrine falcon is now classified by the federal government as an endangered species; that is, it is in danger of extinction. The American bald eagle, our national symbol, is classified as threatened, which means it could become endangered.

Scientists found that DDT multiplied in concentration as it moved through the links in the food chains. For example, mud at the bottom of Lake Michigan was found to contain only 0.014 parts per million (ppm) of DDT. But the shrimp that lived in the mud retained and concentrated the DDT 30 times, to 0.44 ppm. The DDT became 10 times more concentrated in the fish that ate the shrimp. Concentrations in the herring gulls which scavenged the dead fish were 98.8 ppm, or 7,000 times higher than the small amounts of DDT in the mud at the bottom of the lake.

Scientists also found that DDT does not eventually break down into harmless substances, but can be carried by wind and water around the world. DDT has been found in Antarctic fish, seals and penguins, although Antarctica is the area of the world most remote from pesticide use. DDT has also been found in human mothers' milk, and in human fatty tissues.

The possible threat to health and the damage to wildlife finally prompted the United States and several other countries to ban the use of DDT.

In another case, large numbers of white pelicans were found dead in the western United States. The cause was a DDT-like pesticide called toxaphene, which was used to eliminate rough fish from the lakes the pelicans fed in so they could be stocked with game fish. In one lake, the water contained 0.2 ppm of toxaphene; the concentration in plankton was 77 ppm; the concentration in fish was 200 ppm; and the concentration in the poisoned pelicans was 1,700 ppm. When the pesticide use ceased, the pelican flocks were restored.

Pesticides are not the only toxic substances that can enter the food chain. This is also the case with polychlorinated biphenyls (PCBs), a toxic industrial chemical used in such things as electrical transformers, and mercury, used in the manufacture of medicines, plastics, paper, clothing and camera film. The concentrations of these substances found in Minnesota fish samples and the possible threat they pose to our health have led to the establishment of fish consumption guidelines by the state Department of Health for certain Minnesota lakes and streams.

In 1975, the Mississippi River below the Twin Cities was found to have a PCB pollution problem. In response, the 1976 legislature passed a law severely restricting the use, sale, possession and manufacture of PCBs and products containing PCBs after January 1, 1978.

Waters with suggested limited fish consumption because of PCBs include: the Mississippi River from Minneapolis to Alma, Wisconsin; the Minnesota River from New Ulm to Fort Snelling and Zumbro Lake near Rochester. Women of child-bearing age and children under six years old should not eat fish from these waters. Other people should eat no more than one meal of fish from these waters per week and should avoid large or fatty fish (PCBs accumulate in fatty tissues). PCBs can cause birth defects and skin and liver ailments.

The Minnesota Department of Health has also recommended limited fish consumption because of high mercury levels from the following waters: the Mississippi River from Brainerd to St. Cloud; the Red River near Oslo; the St. Louis River from Brookston to Cloquet; the Straight River from the Freeborn County border to Owatonna; and various lakes within the Rainy Lake watershed. The fish consumption guidelines vary from water body to water body. Mercury can cause nerve damage in humans.

Another heavy metal that is polluting the Mississippi River is cadmium, a residue of electroplating operations. When cadmium is eaten, it replaces calcium in the bones, making them brittle. If cadmium pollution continues, we could someday be in the same situation that countries along Europe's Rhine River face. Because of heavy metal accumulation, sediments dredged from some areas of the Rhine River bottom cannot be disposed of safely. Dumped on land, cadmium enters plants, such as vegetables, grapes and grasses. The grapes are turned to wine and drunk; the vegetables are eaten; the grasses are consumed by cows which produce milk which is consumed by people. When the cadmium-contaminated sediment is used as landfill, the cadmium leaches into the ground, eventually contaminating the groundwater.

Discussion questions:

1. Can you think of any plant or animal that doesn't depend on water to live? Could you survive without water?

2. Can you think of any animals that don't depend on plants or other animals to live? Could you survive without plants or animals?

3. How can water pollution affect the food chain?

4. How can the elimination of a plant or animal species affect the food chain? Draw a simple food chain and eliminate one of the links. What happens to the rest of the food chain?

5. How do you feel about the fact that DDT and other toxic chemicals are spread throughout the environment? Do you think anything can or should be done about it?

Activities:

1. Have the students list what they had for a meal, and draw and follow the food chain down. Incude food processing steps. At what steps can pollutants enter the chain?

2. Food web: Have the students sit in a circle, each with a name tag bearing the name of some component of the aquatic environment (algae, water plant, insect, minnow, sunfish, northern pike, turtle, man, etc.). Using a ball of string, ask one student what he eats (what the organism on his tag eats) and connect the string to the student with that name tag. Do the same with that student, and the next, etc. The end result will be a web of string, showing how each element is indirectly linked to every other element. Cut the string to show how everyone is affected and who is affected most directly.

3. You will need a small paper sack for each student, enough like-colored marbles for 25 per student, and 50 different-colored marbles.

   This exercise is designed to demonstrate how pollution factors go through a food chain. The class is divided into four main groups: 1) water members, 2) plant members, 3) herbivores, and 4) carnivores. Along with the four groups is a group of polluters. Divide the class into the groups following the approximate ratio of 1 water member: 2 plant members: 3 herbivorous animals: 1 carnivorous animal. Place odd or remaining students as polluters. Each member has a sack (with a picture of what type of member he or she is portrayed on the sack) full of 25 marbles of like color. These marbles represent "matter." Just as in a food chain, there is interaction and predation demonstrated in the activity. This interaction comes by having the plant members blindly select two marbles from the sacks of the member below him or her in the food chain. This blind selection of marbles represents cycling of matter through a food chain. The marbles of the water members should be replenished after each complete cycle by having the carnivorous animals give two marbles to the water (could represent decomposition and runoff).

   Run through the cycle a couple of times and explain and discuss the principles behind the game. After a couple of cycles the polluters will introduce "pollution factors" in the form of different-colored marbles. Watch the flow of pollution marbles in any member's sack. That level of the food chain is said to be polluted. How long does it take for a member of each level to become "polluted?" Discuss the principle demonstrated by this activity. Discuss the problems of pollution and how man affects the food chains of various animals.

Comic book, pp. 4-6

Concept: As demanders of modern conveniences, we are partly responsible for the damage done to rivers and lakes as a result of supplying those conveniences.

It is no accident that Minneapolis and Faribault became important grain milling centers. These cities and many others in Minnesota were sited on rivers because of the rivers' potential for generating power to run industries.

As the cities and industries grew, so did the amounts of wastes that had to be disposed of. Today, city and industrial waste discharges are the most obvious sources of river and lake pollution we can point to. In addition to the more than 500 Minnesota communities which discharge wastewater from sewage treatment plants, there are more than 600 Minnesota industries which discharge wastes. These represent industries such as paper production, iron ore processing, oil refining, vegetable processing, sugar production, meat and poultry processing, milk processing and power production.

We obviously cannot now rid ourselves of either city or industry; they are part of the very foundation of our society, and they are interdependent. The city provides industry with both manpower and marketplace; industry provides the city with employment, tax revenues for social services, essential goods and modern conveniences.

Pollution is a byproduct of the production of common goods that our consumer-oriented society is not likely to give up: books, newspapers, telephones, televisions, synthetic fabrics, even the food we eat. As long as we as consumers continue to demand these and thousands of other goods which most people consider essential, we will be responsible in some measure for the pollution that results.

Two pollution problems associated with industry are thermal pollution and acid rain.

Water used for cooling purposes by the manufacturing and steam-electric generation industries produces temperature increases in receiving water. An increase in the temperature of water reduces its capacity to hold oxygen and increases the rate of biological activity. The addition of heat to waters in which nutrients are present tends to increase the growth of algae. Higher temperatures may also influence the toxicity of a toxic compound.

Temperature changes also play an important role in the physiology of fish and other aquatic animals. Temperatures higher than those normally experienced, particularly during summer months, can be detrimental to aquatic organisms in a variety of ways. Organisms may be more susceptible to disease or to poisoning, their food supply or their ability to catch food may diminish, and the inability to reproduce or to compete successfully with other aquatic organisms may eliminate a population. The elimination of one species in the food chain may change the ecological balance and cause significant changes in the other species present.

The phenomenon of acid raid starts when a fossil fuel such as coal is burned or a sulfur-bearing metal is smelted, releasing sulfur dioxide or nitrogen oxides into the atmosphere. These compounds mix with water vapor and form sulfuric or nitric acid which is carried in clouds over long distances, finally falling to the earth as rain. The rain in most cases is only mildly acidic, but in some extreme cases it has been as acidic as vinegar.

The damage done to water by acid rain depends on whether the environment is rich in calcium, magnesium or other alkalines that neutralize the acid.

The Canadian Shield, a calcium-deficient geological region, is very susceptible to damage by acid rain. The Shield stretches across most of eastern Canada and the northern areas of Minnesota, New York and New England. Lakes in Minnesota's Boundary Waters Canoe Area are showing signs of acidification.

Acid rain affects the reproduction and survival of fish. With no alkalines present to neutralize it, the acid buildup stifles the hatching of fish eggs and kills plants. The water eventually "dies" --it can no longer support life.

The installation of scrubber systems to clean the smoke given off by these industries, and furnaces that burn more efficiently can significantly decrease the amount of acid rain created.

Discussion questions:

1. Who do you think is responsible for water pollution? How are they responsible?

2. Are you part of the pollution problem? How?

3. If pollution is a byproduct of our lifestyle, are you willing to change some of the things you do that create the demand for items whose production creates pollution? What would you change?

   --emphasize alternatives rather than "sacrifice"

4. Should industry be made to clean up its waste discharges?

5. How does industry pay for the costs of devices that reduce pollution?

   --the costs are passed on to the consumer through higher product prices

   Are you willing to pay more for products if it means we will have a cleaner environment?

6. If we are not willing to change our demands and/or pay higher prices for products, what will happen to the environment?

7. If acid rain kills the fish in northern Minnesota's lakes and rivers, what do you think will happen to northern Minnesota's economy (tourist dollars)?

Activities:

1. Take a tour of a local industry or have a guest speaker from a local industry come in and discuss his company's manufacturing process and what the company is doing to prevent water pollution.

2. Do a report on the manufacture of a product. Include what resources and materials are involved in the manufacturing process, what waste byproducts are left to be disposed of, how they are disposed of, and what role water plays in the manufacturing process.

Concept: If everyone thought "just one" piece of litter didn't matter, we would spend our days surrounded by garbage.

(Also see final concept, p.43.)

We live in a throw-away society. Disposable products--lighters, razors, flashlights, pens, paper plates, plastic cups and spoons--are used by almost everyone. Product packaging is also "used" by almost everyone. Half the nation's paper, three-fourths of its glass, a third of its plastics, 40 percent of its aluminum and 8 percent of its steel are used to wrap and decorate consumer products.

All of these disposable items, and everything else we throw away, whether at home or in industry, is waste. If we put all of the three millions tons of solid waste we generate annually in Minnesota in one place, it would fill a garbage bin about as high, wide and long as the IDS Center is tall (57 stories). And we're running out of space and adequate treatment facilities to deal with it. If we ignore the garbage bin and carelessly throw litter on the sidewalk, in the street, in parks, rivers and lakes, we can make Minnesota a dirty, ugly, unpleasant place to live.

Solid waste collection, processing and disposal are expensive, whether we pay for them as individual users of services or as community taxpayers. In fact, the National League of Cities reports that communities spend more on solid waste management than they do on police, fire protection, and every other service except education.

The expense and the lack of landfill space are only part of the problem. Some of our wastes are too dangerous to be disposed of in ordinary sanitary landfills because they may pose a hazard to our health and to our environment. These hazardous wastes may be toxic, irritative, corrosive, flammable or explosive. Hazardous wastes include used oil, acids, solvents, chemical sludges, pesticide residues and other leftovers from manufacturing processes.

In Minnesota, hazardous wastes are produced in metal fabrication, food processing, motor vehicle maintenance, oil refining, and in the production of building materials, leather goods, machinery and electronic equipment, among other things.

While the amount of hazardous waste we generate in Minnesota (about 150,000 tons each year) is only a small percentage of our total waste, improper handling of hazardous wastes can be disastrous. Across the country, examples of past and present hazardous waste mismanagement are showing up as severe public health dangers. "Love Canal" and "Valley of the Drums" have almost become household words. Groundwater has been contaminated by mishandled wastes, making it unsafe for use. Land has been poisoned by mismanaged chemical wastes, damaging vegetation and wildlife. Human contact with improperly handled wastes has been blamed for cancer, birth defects, miscarriages and death.

Here in Minnesota, too, we've had problems. In 1972, 11 persons in Perham, Minnesota, were stricken with arsenic poisoning from well water contaminated by pesticides buried 40 years earlier. More deposits of the same pesticide--used to fight grasshopper plagues in the '30s and '40s--have been discovered in Minnesota in the past year, in one case causing the death of 12 cattle.

We do have the technology to handle hazardous waste safely. Some hazardous wastes, such as acids, caustics and solvents, can be chemically neutralized. With air pollution control equipment, flammable wastes can be incinerated. Other hazardous materials can be recycled--used as raw materials by another industry. Finally, hazardous materials can be safely managed in specially designed landfills.

In Minnesota, about 60 percent of our used oil, the most common hazardous waste, is recycled--burned as fuel or rerefined into lubricants. Some hazardous wastes are shipped to processing facilities and landfills in other states. A very small fraction is incinerated or stored on the generator's property.

But more than half of the hazardous waste generated annually in Minnesota is not accounted for after it is generated. It is strongly suspected that most of the unaccounted-for waste is either buried unsafely, threatening surface and ground waters; poured into sanitary sewers, where it is treated inadequately and released into rivers; or illegally dumped into storm sewers and ditches.

Currently, no commercial hazardous waste processing and disposal facilities are available in Minnesota to waste generators. Thus, the only legal way to dispose of wastes other than recycling or incineration--techniques which may be too expensive for smaller industries to use--is to ship the wastes to other states where facilities exist. This method is also expensive. Shipping costs range from $70 to $200 per ton, and these other states are expressing reluctance to continue accepting wastes from outside their borders. The expense of handling wastes properly tempts some firms to hire "midnight dumpers" to get rid of the waste illegally for less money.

Either way, consumers end up footing the bill, through increased prices, higher water purification costs or, worse, damage to public health and welfare.

The 1980 Legislature took a significant step in environmental protection when it established a framework to provide proper management of the hazardous wastes generated in our state. Minnesota's new Waste Management Board is following carefully spelled out procedures in the preparation of a statewide hazardous waste management plan, and in the selection of sites for commercial hazardous waste processing and disposal facilities. Hazardous waste regulations, established by the Minnesota Pollution Control Agency, will apply to these facilities.

The MPCA also has in effect a monitoring system which requires waste generators to track hazardous wastes from their point of generation to their point of disposal. Hazardous waste generators must report to the MPCA how much and what kind of hazardous waste they generate, and how they propose to manage that waste. This "cradle-to-grave" monitoring will ensure that waste generators and the state will know that hazardous wastes are being properly disposed of.

Discussion questions:

1. Where does your family's trash go when it disappears into the garbage truck every week?

2. How much land does your community use for dumps and sanitary landfills? How could that land have been used if there weren't so much solid waste generated?

3. How much waste does your household generate every week?

4. How can you decrease the amount of waste your household generates?

5. What disposable items do you use? Which ones can you do without? Which ones have reusable counterparts (e.g., paper plates--china plates)? Why do you use disposable products instead of reusable ones?

6. Can you think of any positive uses for waste (alternatives to throwing it away)?
   --recycling, repairing and reusing, giving to charity things someone else could use

7. What are some reasons for product packaging?
   --food preservation, cleanliness (e.g., keeping medical supplies sterile), convenience for shipping and shelf display, decoration to catch your eye so you'll buy it.

Activities:

1. Have the students bring in unnecessary product packaging (or pictures). Have them redesign the packaging. (Paper and cardboard decompose readily; plastic doesn't.)

2. Have the students go around the schoolgrounds and collect all of the litter of any type they can find. They should develop a coding or keying system that will allow them to later map all of the litter. (They could attach tags to the litter and note the location it was found in.) When the students get back into the classroom have them divide the litter up into types. Have them map the schoolground as to the litter types that were found. Are there any patterns of litter? Are there areas where it seemed that there was more litter of one type?

3. Have the students start to come up with some solutions as to how to help alleviate the litter problem. From the data on litter mapping one could tell where most of the littering was being done around the school. This could dictate the location for waste paper basket placement, etc. Have the students go as deeply into this activity as possible, with the making of "no litter" signs and a general litter campaign throughout the school.

4. Make a collage or piece of art work with the litter the students collected from the schoolgrounds. Have them try to express a feeling about litter. Display the art pieces to gain school recognition and awareness.

5. Have the students write about litter. Have them create a poem that gets across their feelings on litter and land pollution. Let them be creative and open. Display the poems around the classroom or school in order to promote action and more awareness.

6. Take examples of the types of litter the students collected from the schoolgrounds, place them in quart glass jars full of water and label them. Put the jars in a well-ventilated area of the classroom. Make a chart like the following:

TYPE OF LITTER	TYPE OF CHANGE DETECTED									
Day	1	2	3	4	5	6	7	8	9	10

Do certain types of litter break down more quickly than others? Which types break down the easiest? Which types break down the hardest? Have the students come up with some ideas to help solve the litter problems.

Comic book, pp. 10-11

Concept: Man's activities have speeded up the natural forces of erosion and siltation into a major pollution problem.

Erosion and siltation (or sedimentation) are part of a natural cycle. In a natural environment, the normally low rates of erosion and sediment deposition are handled by natural biological processes. Man's activities have upset the balance of this natural cycle by speeding up the natural forces of erosion and siltation to the extent that natural processes are no longer able to absorb the pollutants introduced into the system. The speeding up is largely the result of the loss of natural vegetation on riverbanks and lakeshores and the drainage of wetlands, caused primarily by construction and agricultural practices.

Vegetation helps prevent erosion, and therefore siltation, in a number of ways. Vegetation intercepts rainfall, reducing runoff and retarding erosion by decreasing runoff velocity; it improves the porosity of the soil and increases the soil's water storage capacity; and its roots physically restrain soil movement.

According to the Minnesota Pollution Control Agency, sediment is a major water pollution problem. The dirty brown or gray appearance of a river after a rainstorm is due to sediments washed in from croplands, unprotected forest soils, overgrazed pastures, or the bulldozed developments of urban areas.

The presence of sediment generally increases the cost of water purification, reduces the value of water recreation, adversely affects fish habitat and reduces the water carrying capacity of rivers and reservoirs.

When sediment leaves the land and enters the water system, it can remain in suspension or settle to the bottom. Either situation may cause direct and indirect changes in water quality and in aquatic life.

Toxic substances, such as pesticides and heavy metals, adhere to sediment and may accumulate on the river or lake bottom and in aquatic life, contaminating the food chain. Fertilizers and other nutrients also adhere to sediment and accelerate plant growth. The same nutrients that spur the growth of crops also cause excessive algae and weed growth in rivers and lakes. Sediment also absorbs heat and may lead to thermal pollution (see guide, p. 11).

Sediment changes the numbers and kinds of organisms in water. It decreases the amount of light available to plants for photosynthesis and germination, leading to a decrease in the amount of food available for fish and other organisms. It also decreases visibility, altering feeding patterns and predator-prey relationships.

Suspended sediment can cause fin rot, alter fish gills, affect the respiratory rates of fish and, in extreme cases, cause suffocation. Abrasions caused by sediment make fish more susceptible to infection.

Deposition of sediment on stream or lake bottoms can destroy habitat by covering formerly variable gravel bottoms with uniform, fine particles.

Lakes are more sensitive to sediment pollution than are rivers, partly because lakes generally cannot rid themselves of added sediment. Lakes are affected by even small additions of nutrients and changes in water transparency and depth, all of which are potentially caused by sediment.

A river may eventually transport sediment out of the initial deposit area. However, this removal, and the recovery of the aquatic ecosystem, may take years, depending on the initial magnitude of the deposition, the river's ability to transport the sediment and the availability of nearby healthy organisms to recolonize the damaged sites. Of course, the sediment could be redeposited farther downstream, adversely affecting those areas in turn.

In addition to its direct effect on aquatic life, sediment may adversely affect recreation, irrigation, industry and drinking water. Reduced waterway capacity due to sedimentation also causes flooding, reduced water storage, reduced navigability and increased dredging costs.

Suspended sediment in irrigation water may cause problems such as clogging of irrigation equipment. Suspended solids in irrigation water may also form crusts on top of the soil which decrease water infiltration, inhibit emergence of plants, impede soil aeration and coat plant leaves, thereby inhibiting photosynthesis.

Purification of drinking water can be affected by suspended solids because such solids provide refuge for microorganisms from the disinfecting effects of chlorine. Turbidity also causes an undesirable appearance in drinking water.

Other damage is a result of deposition on lake and river beds. The resulting higher floor of the water body reduces water carrying capacity. Reservoirs that fill up with sediment have reduced water storage capacity. Streams that have reduced water carrying capacity due to sediment will flood more easily, causing further erosion and sedimentation. Harbors and rivers suffer from reduced navigability. Dredging is often necessary to open channels and reservoirs, thereby causing an additional problem--disposal of the removed sediment. Wetlands and ponds that completely fill up with sediment cause losses in water storage as well as losses of wildlife habitat and areas of aesthetic value.

Waters in the major farming areas of the state have sediment levels much higher than those in non-farm areas, according to the Minnesota Pollution Control Agency. Many times soil conservation is also the key to improved water quality in rural areas.

According to the U.S. Soil Conservation Service, about 61 million tons of soil erode from Minnesota farms each years. However, as a result of farmer participation in soil conservation programs, the amount of farmland eroding at unacceptable rates has been reduced from 11.2 million acres in 1967 to 8.3 million acres today. The amount of cropland in the state is 22.9 million acres.

Leaving crop residue on the surface of the field after the harvest is one of the best ways to protect the soil from wind and water erosion. The soil is most vulnerable between April and mid-July, when the snow is gone, the soil has thawed and the protective canopy of the new crop has not yet developed. The residue lessens the impact of rain as it strikes the soil, helps hold raindrops where they fall, improves infiltration of water into the soil, physically holds down the soil and prevents wind erosion.

Feedlots

Feedlots (feeding pens), where large numbers of livestock are raised in concentrated areas, generate tremendous amounts of wastes. According to Minnesota Pollution Control Agency estimates, the state's 90,000 feedlot operations produce a total of 162 million pounds of animal manure every day.

Pollution from feedlots occurs when water crossing feedlots washes off or dissolves pollutants from the animals' manure and runs off, carrying the pollutants into ground or surface waters.

Feedlot runoff carries a variety of pollutants. Most important are the pathogenic organisms present on and around the animals and their excretions. Each type of livestock harbors different pathogens which can cause different diseases in humans as well as in other animals.

Feedlot runoff also contains phosphorus and nitrogen compounds. Phosphorus, and sometimes nitrogen, can accelerate lake eutrophication (enrichment and natural aging--see guide, p. 24), and can also damage rivers. Ammonia, a nitrogen compound, may cause disease in humans and some animals.

Finally, there is a broad range of organic materials whose decay requires oxygen. Oxygen depletion in lakes and rivers can cause fish kills and odors.

The PCA estimates that 10 to 15 percent of the 90,000 feedlots in Minnesota represent hazards to water resources. The geology of southeastern Minnesota, which is particularly sensitive to water pollution problems, also underlies the principal livestock raising area of the state.

The Karst geology of southeastern Minnesota is characterized by a land surface with numerous depression or holes which were formed by the action of water dissolving the limestone and bedrock. These dissolved channels and cavities facilitate the spread of pollutants throughout the surface and groundwater system. Polluted surface water can drain into these channels and cavities, which enter directly into underground drainage pathways leading to groundwater supplies.

Discussion questions:

1. Are there erosion problems in your community, neighborhood, on the schoolgrounds? If so, what are they caused by? What do you think could be done to correct the problems?

2. What would you do if you worked for the government and wanted to stop erosion in Minnesota? Discuss the economic consequences of your proposals.

3. What do you do that causes erosion?
   --e.g., taking shortcuts that wear paths on hillsides, riding trail bikes on hills

4. Why do farmers try to farm right up to the river's edge?
   --economic pressures. Farming (chemicals, equipment, etc.) is an expensive operation, and food prices have not gone up as fast as the price of everything else. Therefore, farmers have to make use of every possible bit of land to make money.

5. What obligation do farmers have to the people downstream who need or use the river?

Activities:

1. Visit a local stream, or walk around the schoolgrounds after a rainstorm, and look for erosion problems. Discuss the causes and possible solutions.

2. To illustrate sedimentation: put water in two clean quart jars. To one jar add some dirt and shake it up. Note the difference in color and clarity. Discuss how you would be affected by the sediment if you were an aquatic organism.

3. To illustrate reduced waterway capacity: Put two cups of water into a large glass jar and mark the level on the outside of the jar. Empty the jar and put a couple of inches of dirt on the bottom. Add two cups of water and mark the level. It should be higher than the previous level mark. Apply this situation to a river or lake. As the water level rises because of accumulated bottom sediments, what will happen on shore?

4. To illustrate the role of vegetation in erosion control: Take two cake pans or shallow boxes lined with plastic and fill them with dirt. Leave the dirt bare in one and plant in the other box to cover the dirt (twigs, a piece of sod, small houseplants, weeds, or, if time allows, start some seed). Give the plants some time to establish themselves. Tilt the boxes to simulate a slope (do this outside on a sidewalk or over a plastic sheet). Pour water down the slope with a sprinkling can to simulate rain and note the amount of soil that washes off of each onto the sidewalk.

Concept: Proper treatment of sewage on shorelands is important to protect the public health and the state's public waters.

As the state's population grew and the interest in water recreation increased, more and more summer cottages were built on lakeshores, in areas that could not easily be tied into municipal sewer and water systems. Inadequate sewage disposal methods resulted in pollution which adversely affected the value of the water for recreational activities such as boating, water skiing, swimming and fishing--the very activities which shoreland owners were seeking.

When raw sewage or septic tank effluent is discharged into our water, both health and eutrophication hazards are created. Raw sewage or septic tank effluent contains disease-causing organisms. Many diseases are water-borne and the discharge of these organisms into public waters creates a health hazard.

Eutrophication means that the water has been overfertilized. The nutrients in sewage that fertilize waters cause algal blooms and excessive weed growth. Even if we chlorinate and kill all disease-causing organisms in sewage effluent, the nutrients are still present to fertilize our lakes and streams.

Over time, lakes naturally tend toward a eutrophic state. Deep lake basins begin to silt in and accumulate bottom sediments. This results in much larger acreages of shallower water, with an accompanying increase in plant life. This process continues until many lakes eventually fill up and become marshes. The ultimate result of this process is dry land. This natural tendency of lakes to change from deep infertile lakes to shallow fertile ones is hastened by man's activities.

A properly designed home sewage system can be an effective treatment method, and can protect our waters from both disease-causing organisms and excessive nutrients.

The home sewage treatment system, sometimes referred to as an onsite system, consists of two parts: the septic tank and the soil absorption system. Both are essential to the proper operation of the system.

The sewage solids settle to the bottom of the septic tank and are broken down by bacterial action. The septic tank must be large enough to allow most of the solids to settle out as the liquid slowly flows through the tank.

The liquid which is discharged from the septic tank is called effluent. The effluent is a slightly cloudy liquid with some fine solids in suspension, disease-causing bacteria, and nutrients. It must be treated in a safe and sanitary manner.

The treatment of effluent is the function of the soil absorption system. The effluent is filtered by the soil, which breaks down and renders harmless the solids, chemicals and bacteria. The nutrients attach themselves to soil particles, a process called absorption. (An illustration of a proper sewage treatment system is in the comic book, p. 21.)

Discussion questions:

1. What happens when you pour something down the drain in your house? Do you know where the wastes go? Do you have city sewer or an onsite sewage treatment system?

2. Are there any lakes in your area with eutrophication problems? Do you know or can you guess what is causing the problem?

3. How do lake pollution and eutrophication problems affect recreational activities?

4. Since lakes naturally tend to become eutrophic anyway, does it matter how fast it happens? Can you think of any new lakes that are being formed to take the place of the ones that are becoming eutrophic?

5. If you lived on a lake, how would you feel if your lake was turning into a marsh? How would it restrict your use or enjoyment of the lake? How would it affect your property value? Would you be willing to spend money to improve the condition of the lake (or the condition of your septic system, if that were part of the cause)?

Activities:

1. Visit a lake in your community. Discuss how far eutrophication has advanced and what might be the causes. Draw the steps in the eutrophication process to depict what the lake might have looked like when it was first formed to the time when it will become dry land. Include the adjacent land uses.

2. Ask your local zoning administrator or a representative of the DNR to come in and explain the shoreland zoning standards for a lake in your community. Ask whether there have been any changes in the condition of the lake since the zoning was implemented.

Concept: Building too close to a river or lake increases the risk of flood damage.

Every year rivers and streams in Minnesota overflow their banks. It is estimated that flooding causes $60 million in average annual damages.

Rapid snowmelt in spring, sometimes aggravated by rain, causes major floods. Severe summer thunderstorms, especially in the Cannon, Root and Zumbro river basins and in those watersheds drained by streams into Lake Superior, often cause local flooding.

Annual flood damage in Minnesota is about evenly divided between agricultural and nonagricultural land. More than 30 percent of state flood damage occurs in the Red River Valley, where floods cover vast expanses of cropland. The greatest amount of damage, more than 35 percent, occurs in the Minnesota River basin.

In urban areas, large amounts of impervious surface (streets, sidewalks, parking lots, buildings, etc.) worsen flood conditions by decreasing the soil area which can absorb water and by increasing the amount of runoff.

Early settlers in Minnesota usually arrived by river and settled on the floodplain, the relatively level land next to a river that may be submerged by floodwaters. The floodplain offered settlers fertile soil for crops, wild game and fish, woodlands for fuel and lumber, and a convenient source of water for domestic and industrial uses and transportation. Eventually, cities and industries grew on the floodplain. And eventually the river flooded.

Dams were often built to prevent floods. But dams don't prevent floods completely. Upstream of the dam a reservoir of water is created--land that is permanently flooded. Often the amount of land permanently flooded by the reservoir is larger than the amount of land downstream that is protected. And the protection may be only temporary. The reservoir of a dam built on a river that carries sediment will fill in, which will reduce its water storage capacity and make it useless for flood control.

Channelization is another method that has been used for flood control. To channelize is to dredge out and widen a stream to turn it into a straight ditch. This increases the stream's flow capacity--enables it to more quickly carry downstream the high waters of spring snowmelt and heavy rainstorms. This prevents floods in the channelized area, but because this area is no longer part of the storage capacity of the watershed, it causes worse flood conditions downstream.

Channelization is also used to help drain wetlands so they can be used for cropland. Wetlands act as a "sponge" to absorb water in the hydrologic system. When they are drained, these storage areas are lost.

The effects of channelization on the environment are disastrous: the banks and bottom are gouged and stripped of vegetation and aquatic habitat; erosion is increased because of the lack of vegetation and because channelizing accelerates runoff; and the aquatic organisms on which fish feed are reduced, which in turn reduces or eliminates fish populations.

Despite the construction of flood control structures, flood damage costs continued to rise in Minnesota because we continued to build on the floodplain. Floods cannot be entirely prevented or controlled. What can be controlled is the type of activity or building that takes place on the floodplain.

In 1969 the state legislature created the Floodplain Management Program, which helps communities develop floodplain management regulations based on sound hydrologic data (see comic book, p. 19).

There are many uses for floodplains that don't involve structures that are damaged by flooding. Recreational open space uses such as parks, campgrounds, golf courses, trails and hunting areas can be flooded with almost no damage.

The 100-year flood

A 100-year flood is a major flood that has a 1 percent chance of occurring in any given year. A 100-year flood may happen more than once in a century. Floods of this magnitude have occurred in Mankato in 1952, 1965 and 1969. In the summer of 1972, Duluth suffered two 100-year floods.

Discussion questions:

1. Have you ever been in a flood or seen a flooded area? Where was the most damage caused?

2. Who should pay for flood damages?

3. Are there any wetlands in your area that have been drained or any rivers that have been channelized? What were the reasons for the draining or channelization? What were the results, both positive and negative, of the draining or channelization? Who or what benefited and who or what was harmed?

4. What happens to wildlife when the rivers and wetlands they depend on are channelized or drained?

5. Are there any flood control structures such as dams in your area? How do they work?

6. Why are some areas more prone than others to flooding?

7. Why should the state government be concerned about flooding?

8. Does your community have a floodplain? A floodplain ordinance?

Activities:

1. Appoint a zoning commission and bring before it various development projects for a floodplain area (industries, housing developments, parks, golf courses, etc.). Debate the merits of each project and decide which ones should be approved.

2. If your community has a floodplain ordinance, ask the local zoning administrator to come in and explain it to the class.

Comic book, pp. 14-15

Concept: Unwise development can destroy the natural qualities that first attract us to an area.

Our heroine found the kind of place many of us dream about for a home--a beautiful area next to a river, full of trees and wildlife. But what she did when she built her house destroyed many of the qualities that first attracted her to it. Cutting down trees and stripping the land of other vegetation increased erosion and sedimentation and destroyed wildlife habitat.

Discussion questions:

1. What does the girl like about the place?

2. What do you like about it?

3. What can be some of the consequences of building next to a river or lake?

4. What can be done to minimize the consequences of a building project?
   --avoiding steep slopes, maintaining as much vegetation as possible, using color tones and designs that blend into the natural landscape

Activities:

1. Have the students draw the kind of place where they would like to build their dream home. Then have them draw in the house. What did they have to move or cut down to make room for the house? Discuss the consequences of the building project--erosion, destruction of wildlife habitat, etc.

2. Have the students design a home that doesn't destroy the natural environment they value on their "dream home" site. Suggest making the home as compatible with the area as possible. What would they build the house out of? Where should it be built?

Concept: Zoning laws not only put restrictions on you, they protect you by putting restrictions on your neighbors.

The girl was thoughtless or ignorant and there were no rules she had to follow when she built her house. She damaged the river through erosion and siltation, and drove away the local wildlife. She also cut down all the trees in front of her house so she could have a beautiful view of the natural woods across the river. She didn't stop to think: 1) that anyone would build across the river; 2) that whoever built across the river wouldn't want a beautiful view of her house, but would prefer to see trees; and 3) that such a radically different type of development from her own would be across the river in this recently very natural area. This is an extreme example of what can happen when there are no zoning laws or when there are poor zoning laws, the rules we have to follow when we build or develop land.

Zoning is a process through which a community divides itself into two or more districts or zones, allowing only designated land uses in each district and imposing certain development standards on all future construction and other land development activity. Ordinance provisions must be reasonable, nondiscriminatory, based on a comprehensive plan, and related to the health, safety, morals and general welfare of the community. Most existing land uses and structures are not affected, even though they may not conform to the ordinances.

Zoning is done at the local government level--city, county and township. However, since 1969 state law has required zoning and other controls in certain areas to protect the natural environment.

Most zoning is done for the following reasons:

1. To protect property values by prohibiting the development of incompatible or substandard uses on nearby land.

2. To improve the quality of the physical environment by screening or eliminating unsightly uses of land such as junk piles and dumps, regulating billboards, preventing lake pollution, etc. This can make a community more pleasing to residents, and to recreation seekers or new industry the community wishes to attract.

3. To prevent legal and personal problems that might result from the development of incompatible uses on adjacent tracts of land; for example, disputes between farmers and rural residents or between drive-in restaurants and summer home owners.

4. To protect public health and safety by preventing development that could lead to ground and surface water pollution, by keeping structures a distance apart to reduce fire hazard, by providing room for use of firefighting equipment, etc.

5. To preserve and develop the economic base. Where the local economy is based on natural resource-based industries such as agriculture, forestry, recreation or mining, the economic health of the community may be directly related to the health of the natural resources. In more industrialized areas, local governments that keep taxes reasonable and provide suitable sites and superior public services for commercial and industrial development are more likely to attract businesses which help the local economy.

6. To facilitate efficiency in providing public services and facilities and to protect the public investment in parks, highways, etc.

Zoning ordinances are usually developed by citizen groups called planning commissions. The commission members are appointed by the local elected government representatives (county commissioners, town board, city council) to study the community, plan its future development and draft zoning ordinances to implement a comprehensive land use plan. They must become familiar with community needs and goals and develop an ordinance that reflects them. The planning commission is usually assisted by a professional planner.

Before a zoning ordinance is officially adopted by the local unit of government, public information meetings and a public hearing are held to give all viewpoints a chance to be heard.

Once the ordinance is adopted, a zoning administrator is responsible for making sure that the standards and regulations are followed. The planning commission continues to function and can recommend changes as the need for them becomes apparent. A board of adjustment is appointed and is responsible for reviewing decisions of the zoning administrator when private citizens think they have been treated unjustly, and for issuing variances when the strict application of the ordinance would be unfair.

Zoning districts

A zoning district's label, such as recreation zone, indicates the predominant intended future use. Other uses may also be allowed in the ordinance. The major types of zoning districts include:

Agricultural zones. These are areas of productive farmland where continuation of farming is the most desirable use from the standpoint of the community. This is encouraged by limiting the number and location of rural residences. Utility substations and dog kennels are examples of uses that can be mixed with farming in an agricultural zone.

Forestry zones. These are located in areas not suitable for farming and often combine forestry with some kinds of recreation. Houses and seasonal cabins may be prohibited to reduce the fire hazard. Excluding farming keeps people from trying to cultivate land that past experience has definitely shown to be unprofitable. Forestry districts are usually in relatively remote locations where pulpwood and timber production, processing and sales is one of the mainstays of the local economy and recreation pressures are light.

Recreation zones. Recreation zones may be much like forestry zones except that they include areas more adaptable to various kinds of recreation and are usually closer to a city. They are often multi-purpose zones where recreation, only one of several uses, is particularly important compared with other zones.

Residential zones. In residential zones, developments that can lower the value of private residences are kept out or are required to have a buffer strip around them. Some home occupations and neighborhood stores for convenience shopping are usually allowed.

Lakeshore residential zones. These are special residential districts with regulations especially designed to keep lakeshore frontage and the nearby area attractive and to prevent lake water pollution. Lake frontage is popular but scarce; it is in the interest of the community to prevent haphazard or detrimental development. Because of the interest of the state in preserving water quality and protecting lakes as important natural resources, state law requires these areas to be zoned (see comic book, pp. 20-21).

Commercial zones. These are areas set aside for businesses, such as stores, office buildings, bowling alleys, taverns, entertainment, and eating places. They need to be conveniently located near residential areas but where they don't impede traffic. In rural and resort areas commercial zones are used to contain commercial uses rather than have them scattered over the landscape.

Industrial zones. These areas are large, flat and accessible enough to labor and transportation to make good sites for manufacturing and other industries. New plants often need large acreages and tend to locate where they know that other uses will be kept out. These zones are usually near cities and villages where they can be provided with public utilities and other community services at a reasonable cost.

Floodplain zones. Property damage and physical harm to residents have often resulted when homes and other buildings were built in areas subject to flooding. Floodplain zoning is an attempt to prevent future problems. Some recreational, agricultural and other open space uses not involving structures or sources of serious water pollution are normally allowed. In some areas where flooding is infrequent, buildings especially designed to withstand flooding may be constructed. Because of the threat to life and property that results when developed areas are flooded, Minnesota law requires the creation of floodplain districts with appropriate restrictions (see comic book, p. 19).

Special purpose zones. These are zones around airports, public parks, military reservations and other installations where there is a special reason for certain regulations or standards.

Discussion questions:

1. What would the students do as local officials to protect the natural resources of their community as well as allow for economic development? What are the costs and benefits? How would they tell a landowner that he couldn't, because of the public good, put up a factory where he wanted to or build a house anywhere he wanted?

2. How could zoning have protected the house that was built in the preceding section?

3. Do you think zoning is a fair way to control land use, even if it keeps you from doing something with your land that you want to?

4. Can you think of better ways than zoning to control what people do with their land?

5. Can you think of any examples of development or other land uses in your community that are "out of place?"

Activities:

1. Obtain a map of your community and have students draw in what they think the zoning should be. You can turn this into a role-playing exercise by appointing a planning commission and having other students represent local interests in the planning process. Hold a "public hearing" at which the local interests can express their views.

2. Obtain a map of your community that shows the existing zoning districts. Compare it to the zoning districts your planning commission proposed. Discuss why each area was zoned as it was and the advantages and disadvantages of zoning it that way. Discuss improvements you could make to the existing zoning.

3. Ask your local zoning administrator to come in and talk to the class about how your town is zoned and why.

4. Attend a city council meeting at which a variance is to be heard. Find out about the issues involved beforehand.

5. Describe a city or town with an area in its center that is presently a nature area. Draw a map of this city on the blackboard and show the students the area that is now in a natural state. Describe the features of this natural area. (Example - This area of 25 acres has an abundance of trees and shrubs. Several species of birds winter and nest on this area and many small mammals use this area for their homes. There is also a small creek that runs through the middle of this acreage that adds to its beauty.)

   Tell the students that the city council of this city has received a proposal to make this area into a shopping center and parking lots. (Describe a shopping center.) The city council is trying to decide whether to leave the area in its natural state or accept the shopping center proposal. The city council has asked that the citizens (students) write letters to help them make a decision on the proposal. Discuss the nature area and the development proposal, then have the students draft a letter that would help the city council make a decision. During the discussion, play the devil's advocate to spark controversy. For a role-playing activity, students could elect a city council. Appoint representatives to debate the issue.

Comic book, p 17.

Concept: Wildlife is an important natural resource. When we destroy wildlife habitat we destroy wildlife.

Habitat destruction

All forms of wildlife must have a habitat--the combination of food, shelter and water to which a species becomes adapted. Although a number of factors threaten wildlife, the most important is destruction or alteration of habitat by man's activities. Habitat disturbance has been a major factor in the disappearance of some of America's most magnificent bird species, notably the ivory-billed woodpecker, the trumpeter swan, the whooping crane and the California condor. Other major threats to wildlife populations include: direct killing through poisoning for protection of livestock and crops and through exploitation for food, fats, furs, feathers, fun or financial gain; pollution, especially by DDT and other pesticides and herbicides (see guide, p. 7); and introduction of alien competing or predatory species.

Habitat destruction through the growth of cities, industries and housing developments is immediate and devastating. Only those species which can adapt to urban life have thrived--pigeons, roaches and rats are examples. Habitat destruction through farming and forestry began gradually, but has accelerated in recent decades.

When farming first started in Minnesota, it was largely a subsistence operation. Crops were grown for cash income, but a high percentage of the farm land was devoted to the support of farm livestock and to producing the many things a farm family required. Under this system a variety of different crops would occupy various parts of a farm, and part of the farm was always in pasture. Streambanks, road edges, fence rows, corners and woodland patches were "waste" areas that were left uncultivated. Under these conditions, plenty of space was available for farm game--bobwhites, pheasants, rabbits, skunks, mink, muskrats, woodchucks, etc.

As time went on subsistence farming began to disappear. The demands of growing city populations made it profitable for farmers to concentrate on cash crops and to purchase their needs with the crop income. With the development of farm machinery, the numbers and kinds of livestock needed on the farm decreased, and so did the need for pasture land. With the incentive of higher prices for farm produce, it became desirable to farm the former waste areas, and with the advent of single crop farms, game with more varied cover requirements could no longer survive in agricultural areas. The unfarmable land in river valleys now offers most of the remaining wildlife habitat in agricultural regions of the state.

Forest lands followed a similar trend. Early logging operations were sloppy. Lumbermen simply left logged-over land and moved on to the next area. While this was bad for the forest and forest soils, it favored some types of wildlife. The brushy growth that replaced the trees provided a home for deer, ruffed grouse, rabbits and a variety of other game. Now timber lands are in short supply, and the lumber companies and federal agencies that own them are concerned about timber production for the future. Logged-over areas are often planted immediately with seedlings for the next tree crop. Brush is killed by spraying, eliminating varied wildlife habitat.

Wildlife values

Wildlife have commercial, recreational, aesthetic and scientific value.

Commercial value: For some species the most generally recognized value of wildlife has been commercial--they possess something of value that can be sold for profit. The immediate market value of some species, such as the whale and fur seals, has at times threatened them with extinction. In the 1800s and early 1900s a craze for ostrich and egret feathers almost wiped out those species. The high value of the pelt of the sea otter brought that species near extinction before effective conservation could be organized. The market value of ivory threatens the future of elephants in some parts of Africa.

The exploitation of wild animals for meat has been all but forgotten in countries where it is customary to eat domesticated animals. However, studies in Africa, the U.S.S.R. and Scotland have shown that wild game can often produce more meat and other products of value from the land than can domestic livestock using the same area. The possible value of wild game as a source of new domesticated species of livestock needs more exploration as we try to make the best use of limited land to feed the world's growing population.

Recreational value: In many countries the recreational value of wildlife is of greater economic value than if its meat or hides were directly marketed. In the United States, more than 30 million people spend billions of dollars annually in hunting and fishing, supporting major tourist and recreation industries.

Aesthetic value: In parks and wildlife reserves it is the aesthetic appeal of wildlife that attracts people. They come by the millions not to hunt, but to see or photograph wild animals in natural surroundings. As with hunting, the tourist trade attracted by these areas can be a major source of income. But even if wildlife had no economic value, it would still be worth preserving for its beauty and appeal to the human spirit.

Scientific value: The scientific value alone of wildlife justifies its preservation. In order to maintain the health and productivity of our agricultural lands we are starting to look more closely at how soils and watersheds were preserved before we began to interfere with their natural mechanisms. Wildlife were an important part of these natural biological communities. These areas and their wildlfe must be maintained for study and as standards against which to measure change and deterioration in the lands that we manipulate for commercial production.

The pests and predators that harm croplands, ranchlands and forests reflect ecological disturbance. The accidental or deliberate removal of one species can allow another to increase to unmanageable limits. Vast amounts of money have been spent on chemical control of the California ground squirrel, a range pest. A relatively small expenditure on ecological research revealed that where overgrazing is prevented ground squirrel populations will seldom reach troublesome proportions. For many pests, biological control using natural predators has proven far more effective than the use of poison. But without natural communities to study, natural predators cannot be identified.

Wildlife also has medical research value. Most of the advances in biological and medical research have come through the studies of wild or formerly wild species of animals. Studies of rhesus monkeys have revealed new facts about human blood chemistry and the prevention of disease. Studies of animal behavior reveal new insights into the workings of the human mind. We don't know when some obscure wild animal will provide some needed clue to human health and survival. Perhaps some species we are allowing to vanish from the earth could save the human race if it were allowed to survive.

Discussion questions:

1. What wildlife have you observed in your neighborhood, community, schoolyard? Discuss the kinds of habitat these animals need.

2. Do you know of any places where wildlife habitat has been destroyed because of human activities?

3. How do you feel when you see or hear about wildlife habitat being destroyed?

4. Why do you like or dislike wildlife?

5. Do you think there will be any wildlife left when you grow up? Why or why not? What would it be like if there were no wildlife?

6. How important do you think wildlife is to you?

7. What animals are affected by removal of trees and grass, by erosion and sedimentation? How are they affected?

8. What is the value of a species? Are the eagles worth saving? Animals are disappearing the world over. What responsibilities do we have as creatures on the same planet?

Activities:

1. Have the students draw the kind of wildlife habitat that they are most familiar with. What are the various parts of the habitat? Where do the animals eat, sleep, drink, and loaf around? Where could the animals do these things if parts of the habitat were destroyed? What types of human activities help or destroy this wildlife habitat?

2. Have the students list all of the objects in the classroom or their home that they would come in contact with in an ordinary day. Go through the lists and determine what things required there to be animals. Imagine that the animal necessary for the production of an object were made extinct or removed for good from the world. Could we get along without the product that it helps produce? Which of the objects listed were luxuries? What is a luxury and what is a necessity? If fur coats are not mentioned in any of the lists bring it up on your own list. Are there alternatives to the production of any of the products on the lists? Are there any objects on the lists that are definitely harmful to animal populations or habitats?

3. Pick up a couple of daily newspapers and search for articles that may affect wildlife habitat (e.g., new pipeline, changes in agriculture programs, new roads, new building construction). Read the articles to the class and discuss. The students could also find articles and present them to the class.

4. Divide the class into two factions, humans and animals (students can choose their own species or type). There is a stand of timber that acts as a home for the animals and provides "housing materials" for the animals. The humans in the city want to expand the city limits and require the land and its timber for building materials and urban space. Each group should debate why the land should or should not be taken over by the humans. Each group should think out as fully as possible all of the facets of this problem.

5. The birds of the world have charged the people on this earth with destroying wildlife habitat. The birds have hired the members of your class as private investigators to determine if the charges are true. Explain to the students that the birds have asked them to investigate certain problem areas (highway construction, urban sprawl, parking lots, forest fires, clear cutting of forests for paper, agriculture, spraying, and any additional problem areas). The students should discuss each problem to determine whether it is destroying wildlife habitat. When trying to discover the answer to a specific problem, ask them a series of questions:

    1. What is the problem?

    2. Who is affected?

    3. Who is responsible?

    4. Is there a better solution?

    5. Who makes the decisions?

    6. What can you students do?
       Individually? Collectively?

    7. How do you feel about it?

If the students do a good job of investigating the problem they will realize that they contribute to the problem of habitat loss. For example, after discussing the network of highways and land they consume, the students should realize that they use highways like everyone else, so they are partially responsbile for habitat loss from highway construction. When looking at agriculture and the poor land use practices that destroy wildlife habitat, the question should be posed to them: "Who is the farmer producing food for?" (You) When discussing problems of logging operations for lumber and paper, ask the question: "Do you have wood in your house or do you use paper?" Cover all the problem areas of wildlife habitat loss and discuss them with the class. Now ask the questions: "What will you tell the birds of the earth in answer to their question: - Who is responsible for habitat destruction?" "What are you going to do about it?"

Comic book, pp. 18-25

Concept: Rivers and lakes that cross or are surrounded by several local government jurisdictions can often be best protected by a coordinated state program.

Historically, development in Minnesota has tended to center around and along bodies of water. Some large lakes and most rivers fall under a number of local government jurisdictions--counties, cities and townships. Each of these local units has its own aims, its own pressures, and in many cases its own zoning regulations. Providing a consistent level of protection for a water resource under these conditions is difficult. For example, erosion, sedimentation and pollution problems in even one county along a river will have a harmful effect on the river in counties downstream.

State zoning programs establish minimum standards which cannot be weakened, thus providing a consistent, minimum level of protection for the river or lake as a whole. These standards do not, however, prevent protection-minded local governments from applying more restrictive zoning provisions.

Local governments often resent what they consider the intrusion of state government into local affairs. They believe state regulations which would restrict development to a certain extent interfere with their aims: to attract residents, business and industry to widen their tax base and help their communities prosper. However, the short-term benefits they would enjoy must be balanced against the long-term problems that could affect a large area of the state if an outstanding water resource were allowed to deteriorate.

State government has resources, both financial and technical, not possessed by local governments, and is geared to take the long-term, statewide view of resource management. It is the state's responsibility to plan for the wise use and management of the state's public resources. Although a river or lake may flow through or be surrounded by local governments, it is a public water, for the benefit of the people of the state as a whole, and not only for the benefit of one county, city or township.

Discussion questions:

1. Who do the state's rivers belong to? Who should be responsible for protecting them?

2. What incentives do people have to protect rivers on their own? What authority do they have?

3. What kind of water problems will we have if everyone does whatever they want to?

4. What are some water problems a city upstream could create for cities downstream?

5. Discuss which level of government is best suited for various activities and services related to natural resources and rivers in particular. Why are the various levels of government suited for what they do? Which level of government do you feel should be responsible for river protection?

6. What kinds of things should regulations address to ensure river protection?

7. How could the state help to decrease the amount of resentment local units of government might feel about the intrusion of state government into local affairs?

8. If you were a state employee assigned to protect a river that flowed through many local jurisdictions, how would you go about it?

Activities:

1. Draw a map of an imaginary river that flows through several counties, cities and townships. Include land uses (agriculture, forestry, housing developments, power plants, etc.) and natural and cultural features (forests, bluffs, archaeological and historical sites, rare plant communities, rare wildlife species and habitats, etc.) Describe problems that are threatening the river's outstanding qualities (overdevelopment, clear cutting, erosion, etc.). Have some of the students play state government workers who are assigned to come up with a plan to protect the river's outstanding qualities. Have others represent local officials, businessmen, farmers, loggers, citizens and other pertinent local interests. Have the students try to work together to come up with a plan that will both protect the river and satisfy the various interests represented. Play the devil's advocate to spark controversy.

Concept: All of us can help make the world a cleaner, healthier, more beautiful place to live.

As When All the Clean Water Is Gone points out, there is no "them" to pin the blame on for our pollution problems. All of use are responsible, through our demands, our wasteful habits, our thoughtlessness. And all of us are responsible for repairing the damage that has already been done to our environment and for preventing any more damage. If we wait for someone else to do it, it won't get done.

Throw-away products contribute to our growing solid waste disposal problem. Returnable containers are less wasteful than throwaways. Real glasses and plates can be washed and reused--paper cups and plates can't. Cloth rags which can be washed and used again can often take the place of the reams of paper towels we now use and throw away.

Product packaging is another, usually unavoidable, throw-away item. However, cardboard and paper containers decompose; aluminum and plastic containers don't. Purchases that are small enough to put into your pocket or purse don't require a paper bag. The plastic bags that things such as bread and market produce come in can often be washed and reused--why waste resources and spend money on boxes of plastic bags?

Recycling is important. Every recycled pound of paper, aluminum or glass is a pound less of waste to dispose of, and a pound less of resources that have to be used to make more paper, aluminum and glass. Some aluminum companies have established recycling centers for used cans (they pay by the pound). White paper and newspapers can be recycled (separately), as can some kinds of nonreturnable glass bottles. Try to recycle things you no longer have a use for (clothes, books, old toys) by calling thrift shops or charities to see if someone else can use them before you throw them away.

If you have a garden, you can start a compost pile to recycle vegetable wastes, coffee grounds, eggshells, grass clippings and fallen leaves into rich, productive soil. This both eliminates the need for chemical fertilizers and decreases the amount of solid waste going into our overcrowded landfills.

Litter attracts more litter. Pick up litter along beaches and riverbanks, and don't leave trash behind to spoil your picnic and camping areas. If there are no trash cans or if they are full, take the trash home with you and dispose of it properly.

Our freshwater supply is limited; don't waste it. Leaky faucets and pipes should be repaired. It isn't necessary to leave the water running when you brush your teeth or wash dishes. Showers use less water than baths, and water-saving shower heads are even more efficient. A bottle of water in the refrigerator makes more sense than letting the water in the faucet run until it's cold every time you want a drink.

"What you do upstream affects someone downstream" can be interpreted in a figurative as well as a literal sense. Almost everything we do has an effect, for better or for worse, on our living environment. The consequences of thoughtlessness and waste may not be immediate--some of the pollution problems we have now were decades in the making--but they will catch up with us--or with our children or grandchildren.

Discussion questions:

1. Discuss your impact on the environment through your everyday actions.

2. What can you do to contribute to cleaner water and a better environment? What can your family, class, community do?

3. If the world ran out of clean water supplies, what would we do? How could we survive?

Activities:

1. Have the students calculate the quantity of water they use in one day. Have them estimate the amount of water they use flushing the toilet, brushing their teeth, washing their hands, taking a bath, drinking, etc. (average use: 40 gallons for a bath, 20 gallons for a shower, 5 gallons to flush toilet). When they have estimated their water usage for each of these activities, add them together to get an estimate of the water each student uses daily.

   The daily usage for each student can be multiplied by the number of students in the class to determine the daily class usage of water. Students can also compute the daily water usage of their school, community, state or nation. Industrial uses can also be included. Key this activity with discussions on the limited water supply on earth. Ask the questions: "Do you think that there is a lot of water wasted on our planet?" "How?" "Do you waste water?" "How?" "Can you think of the ways that you can reduce this waste of our very valuable natural resource?

2. Have the students compute the amount of a paper they use each day. Work out an average of paper per student per day. Multiply this by the number of students in the school. Two thousand pounds of paper equal 17 trees. Calculate the number of trees used by the students each year. Start a paper recycling program in the school.

3. Collect aluminum cans for recycling to raise money for class or school projects.

4. Make posters or other artwork about the value of conservation and recycling and put them up around the classroom and school.

5. Have the students collect and save all the trash they generate for a few days in a plastic bag. This should help them become aware of the waste they are contributing to the world.

6. Have the students act out the role of newspaper reporters of the future. Have them put together a newspaper of the future that deals with the problems brought up in the comic book and guide. The stories shold be prophetic in nature and the students should be encouraged to use their imaginations. Discuss the newspaper. Why do the students think that the things they reported will happen? What is the general mood of the newspaper? Is it pessimistic? Is there much hope?

   Next, tell the students that their job is now to write a newspaper that reports what things were done to alleviate the situations reported in the previous copy of the newspaper. Try to stick with things that could actually be done.

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