GRAY WOLVES GRAY MATTER

Exploring the Social and Biological Issues of Wolf Survival

SECOND EDITION

A PUBLICATION OF THE INTERNATIONAL WOLF CENTER

International Wolf Center™
Teaching the World about Wolves

GRAY WOLVES GRAY MATTER

Jacquelyn Fallon

Gray Wolves, Gray Matter

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The International Wolf Center gratefully acknowledges the contributions of the following people and organizations who helped to make this curriculum possible:

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This second edition of *Gray Wolves, Gray Matter* was funded by a grant from the Institute of Museum and Library Services by an act of Congress. The first edition, published in 2001, was funded by the Minnesota Environment and Natural Resources Trust Fund as recommended by the Legislative Commission on Minnesota Resources.

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The International Wolf Center invited over 30 diverse stakeholders to review and give us feedback on this curriculum. These groups included hunters, livestock owners, animal rights activists, conservationists and other citizens and the Minnesota Department of Natural Resources. We appreciate the feedback that allowed us to create a balanced curriculum that presents many sides of wolf management issues.

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The International Wolf Center thanks the following educators for field testing the *Gray Wolves, Gray Matter* curriculum:

Bill Adamson, Grand Rapids High School, Grand Rapids, MN
Ann Beyer, Ann Arbor Public Schools, Ann Arbor, MI
Joan Hafslund, Belle Plaine Elementary, Belle Plaine, MN
Roger Korf, North Branch High School, North Branch, MN
Kathy Magnusson, Lake of the Woods School, Baudette, MN
Joanne Michet, Friedell Middle School, Rochester, MN
Mary Moriarty, Belle Plaine Elementary, Belle Plaine, MN
Cerisse Murphy, Belle Plaine Elementary, Belle Plaine, MN
Becky Rennicke, Perham High School, Perham, MN
Michael Ruzich, Sandburg Middle School, Elmhurst, IL
Andy Weaver, Stillwater High School, Stillwater, MN

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The International Wolf Center advances the survival of wolf populations by teaching about wolves, their relationship to wild lands and the human role in their future.

Editorial comments and corrections may be directed to edudir@wolf.org, subject line: GWGM Editor
Printed on recycled paper with soy-based ink.

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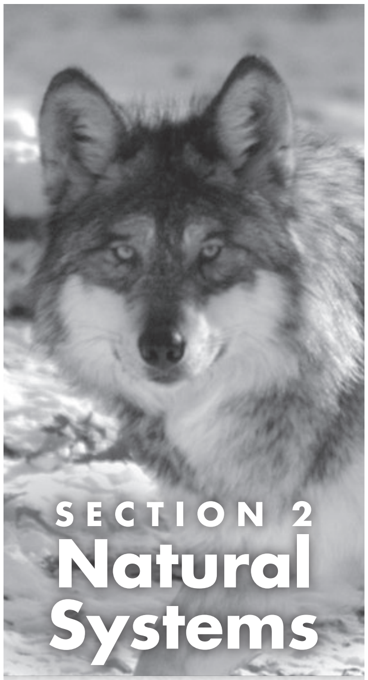
GRAY WOLVES **GRAY MATTER**

Jacquelyn Fallon



Jacquelyn Fallon

Subjects:

physical education, biology, mathematics, geography

Approximate lesson time:

1 hour

Materials:

stopwatch,

Wolf Population Chart,

open playing area,

Wolf Turf cards (Prepare enough cards so the poundage totals about 350 pounds per student and one den per pack. This will allow for about 75 percent survival, which illustrates the point of the game.)

Wolf Turf

Students collect food cards to simulate wolves searching for food.

STUDENT OBJECTIVES:

Upon completion of this lesson, students will be able to

1. Predict how food availability affects wolf populations.
2. Analyze the relationship between pack size and habitat.
3. Calculate their wolf pack's food needs and food acquisition.

VOCABULARY:

carrying capacity • territory • predator • limiting factor • cache • rendezvous site

TEACHER BACKGROUND:

Most wolves live within and defend a home range known as a territory. A wolf spends much of its life hunting, traveling and raising pups within that territory. Occasionally, an individual wolf or the entire pack may wander out of the territory exploring or searching for food. Wolf packs are generally very protective of their territory, and pack members will urinate, leaving their scent throughout the territory to indicate "ownership" of the area. If other wolves come into the resident pack's territory, the resident pack may chase the intruders out or fight with them. Wolves have been known to kill each other over territory.

Wolf pack territory averages roughly 10 square miles per wolf in the pack. Territory ranges in size from 25 square miles or less to over 1,000 square miles, depending on the number of wolves in the pack and the amount of food available. Because wolves generally hunt within the boundaries of their territory, a large enough population of prey animals needs to exist within that territory to sustain the pack over time. The territory can be likened to a refrigerator: it holds the food for the family. Larger packs of wolves often need to have larger territories than smaller packs because they need more area in which to find food. Wolf packs, large or small, may not travel as far (and therefore have a smaller territory) if there is a high density of prey available. The maximum number of wolves or wolf packs an area can support over time is known as its carrying capacity.

The extent to which a wolf pack will defend its territory can be correlated with food availability. If the resident pack is having difficulty finding enough food, this stress may cause them to be especially aggressive in keeping out invaders who might compete for food. Territory boundary disputes with neighboring packs may escalate during times of food stress. Territory size and configuration may also fluctuate over time. The factors, such as food and space, that cause wolf population numbers to increase or decrease over time are known as limiting factors.

By the time young wolves reach two or three years of age, they are likely to leave their home pack's territory. This is called dispersal. Scientists think they may be searching for a mate or better access to food. Sometimes a young wolf will wander as many as 500 miles or more from home and then return to the pack. In other cases, a wolf may "disperse," or leave the pack, and never return. A dispersing wolf faces many challenges, including the hardship of hunting alone and avoiding detection by other wolves that may kill the disperser for invading their territory.

In this game, students act out the pattern of a wolf pack searching for food. The format of this game is modeled most closely after wolf packs' summer travel patterns (although other seasons are represented) in which adult wolves travel alone or in small subgroups and return to the rendezvous site with food for the other pack members and the pups. Pups stay in these rendezvous sites for several months after birth until they are strong enough to travel. The pack uses the rendezvous site as a gathering point while the pups are there.

Like wolves, students may cache food or store it for later. Wolves often do this by digging a shallow hole in the earth, placing the food into it, and pushing dirt back over the hole with their noses. During times of scarce food, wolves will dig up these caches to sustain themselves. In general, wolves eat 4–5 pounds of meat per day but can go a week without eating anything.

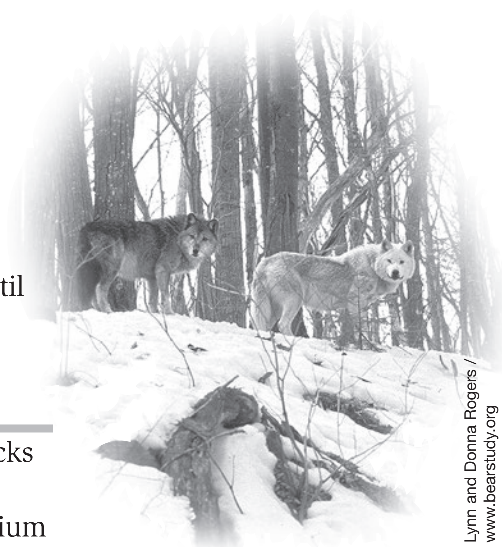
In this game, "wolf recycling" is the limbo place students will go after they "die" of starvation until they are "born" as a new pup.

ACTIVITIES:

1. Divide the class into wolf packs of about five members each.
2. Either outdoors, in a gymnasium or in a cleared classroom, spread out the Wolf Turf cards with dens or foods printed on them. There should only be enough food in the game area for 75 percent of the wolves to survive.
3. Assign each pack an approximate area (a territory) within which they should search.
4. Define areas for the "rendezvous site," "cache" and "wolf recycling."

Round 1:

A. When the game starts, one pack member at a time may walk around quickly in search of food or a den site. They should pick up one card and then must return to the rendezvous site. Students continue searching for food and returning to the rendezvous site for three minutes. After gathering time is up, stop the students and instruct them to add up how much food the pack has collected.



Lynn and Donna Rogers / www.bearstudy.org

National Science Education Standards

Unifying Concepts and Processes

Systems, order, and organization

Evidence, models, and explanation

Change, constancy, and measurement

Evolution and equilibrium

Science as Inquiry

Abilities necessary to do scientific inquiry

Understanding about scientific inquiry

Life Science (5–8)

Regulation and behavior

Population and ecosystems

Life Science (9–12)

Interdependence of organisms

Matter, energy, and organization in living systems

Behavior of organisms

For more correlations, please see Appendix IV.

B. Explain that for every 450 pounds of meat that a pack has collected (an average season's food supply), one wolf survives in the pack. If they have enough cards for all wolves in the pack to survive, the pack remains the same for the next round. If any pack has extra food cards, they get to "cache" them in a secret place and keep them for the next round. If the pack has not collected enough food, the wolves who collected the least amount of food are the first ones to starve. Dead wolves go to "wolf recycling" near the teacher to wait to return as pups in another round. If the wolves have a "den site" card, they can hang on to it for future rounds. *Example: A pack of seven students needs to have collected 3,150 pounds of meat if all members are to survive. If they collected only 2,250 pounds, they lose two wolves.*
C. Collect all the food cards that are not in a cache and redistribute them in the play area again. Tally the populations of each pack and the amount of food found, and record the wolf population on the Wolf Population Chart.

Round 2

A. Same procedure as round 1. This time, however, add the following element: if wolves encounter wolves from a rival pack, they can growl at them and settle the conflict with "rock, paper, scissors." The losing wolf has to give up any food cards s/he has and return to the rendezvous site for 30 seconds before hunting again.
B. After three minutes, packs count their food. Again, each wolf must have collected 450 pounds of food to survive. If anyone has not collected enough food, they may unearth "cached" food and add that to their total. If any pack has 100 pounds of extra food and a den site card, they can trade those in for one pup (someone from wolf recycling). Pups will not hunt during the next round; they just hang out at the den and encourage other pack members to feed them. If the pack does not have enough food for all members to survive, the pups are the first to starve.
C. Collect all the available food cards and redistribute them in the play area again. Tally the populations of each pack and record them on the Wolf Population Chart.

Play as many rounds as you have time for. Four to 12 rounds should give you a sufficient data set for discussion. At the end of the game, graph out the populations of each pack and the food found each time.

Discuss:

1. How does the number of wolves in each pack affect that pack's survival?
2. How does the number of packs in the game affect the student's ability to collect food?
3. How can wolf populations increase in this game?
4. How can wolf populations decrease in this game?
5. Discuss the definitions of carrying capacity and limiting factor. How are these illustrated in this game?

ASSESSMENT:

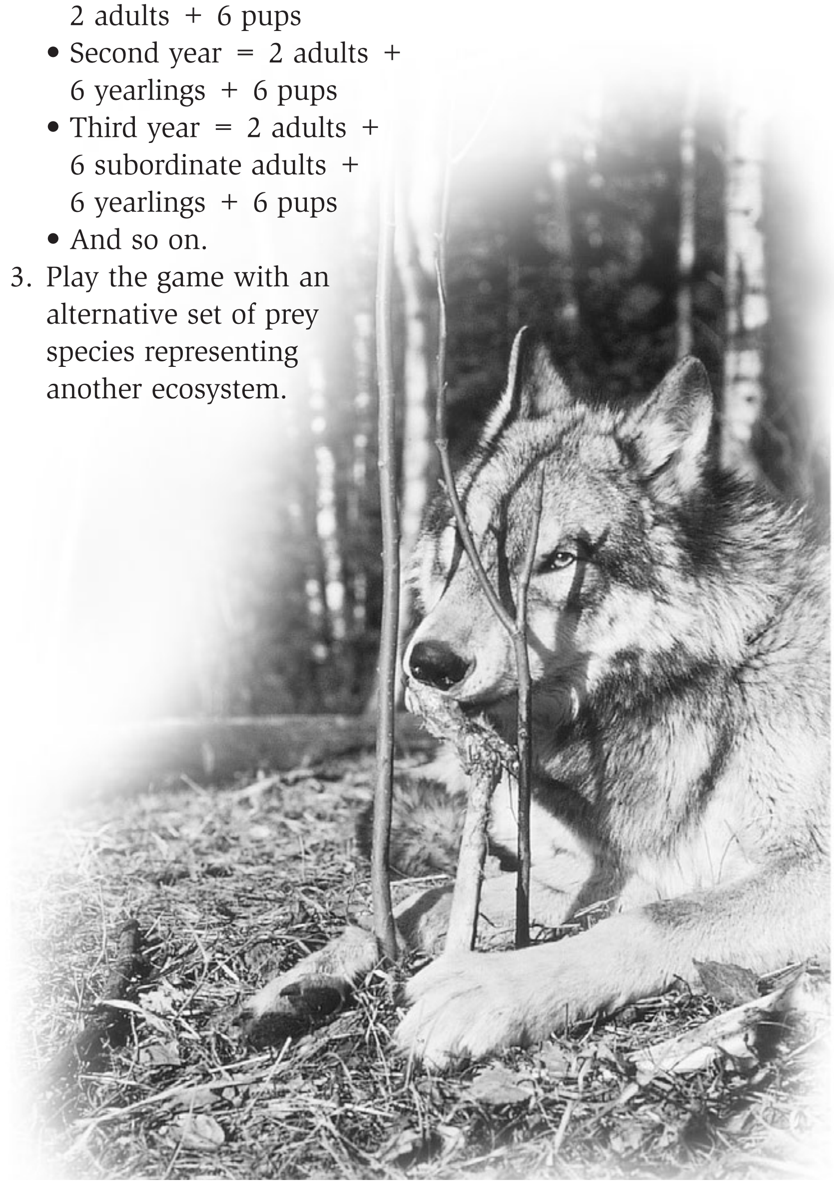
Students will write a one-page reflection paper on what they learned about wolf territory and pack interactions from this activity. Students will answer a short quiz about pack territory dynamics.

Quiz

1. What happens if there is not enough food to feed all members of the wolf pack? *Some wolves will die.*
2. What happens if there is more than enough food to feed a pack? *All pack members can survive, and the pack may produce pups.*
3. What kinds of prey give wolves the most energy per kill? *Elk and bison provide lots of meat for the whole pack. Antelope give less meat per kill, so a pack would have to catch more antelope to feed all pack members.*
4. How is territory size correlated with food availability? *Depending on prey density, a larger territory may provide a larger amount of food.*

EXTENSIONS:

1. Play the game again. Add/remove food cards to demonstrate impacts, such as human hunters, roadkills, competing predators, seasonal changes, etc. Consider adding one card that says "One wolf killed for depredating on livestock." Discuss how human management affects wolf populations.
2. Make another wolf population chart that illustrates what would happen in a theoretical wolf population with zero mortality:
   - First year = 2 adults + 6 pups
   - Second year = 2 adults + 6 yearlings + 6 pups
   - Third year = 2 adults + 6 subordinate adults + 6 yearlings + 6 pups
   - And so on.
3. Play the game with an alternative set of prey species representing another ecosystem.


Janice Templeton

WOLF POPULATION CHART

Number of Wolves

Summer									
Fall									
Winter									
Spring									
Summer									
Fall									
Winter									
Spring									

WOLF TURF CARDS
(cut apart)

elk 500 lbs.	bison calf 400 lbs.	elk calf 50 lbs.	mule deer 200 lbs.
pronghorn antelope 100 lbs.	elk 500 lbs.	moose calf 200 lbs.	Ravens follow you. Lose 10 lbs. for each card collected.
elk calf 50 lbs.	mule deer 200 lbs.	elk 850 lbs.	elk 500 lbs.
Steal a kill from a mountain lion. 100 lbs.	elk 500 lbs.	elk 500 lbs	mule deer 200 lbs.
den	den	den	den

WOLF TURF CARDS
(cut apart)

elk 500 lbs.	Grizzly steals your kill. Lose 500 lbs.	elk 850 lbs.	elk 500 lbs.
mule deer 200 lbs.	elk calf 50 lbs.	moose calf 200 lbs.	Ravens follow you. Lose 10 lbs. for each card collected.
elk 500 lbs.	bison calf 400 lbs.	elk 850 lbs.	elk calf 50 lbs.
elk calf 50 lbs.	Steal a kill from a mountain lion. 100 lbs.	elk 500 lbs	mule deer 200 lbs.
den	den	den	den

Pack Food Budget

NAMES OF PACK MEMBERS ______________________________

____

______________ ______________

____

____

ROUND ONE - Summer

1A. Amount of food collected (in lbs.) ______________________

1B. Number of pack members_____ x 450 lbs. per member = __________

(this is the number of pounds needed for all pack members to survive)

1C. 1A minus 1B = __________

If 1C is a positive number, put that number in your "cache," and you can use it on future rounds. If 1C is a negative number, put 0 in the cache, and you lose one pack member if it is -1 to -450 lbs., two pack members if it is -451 to -900 lbs. and so on.

1D. **Cache**: ____________

(buried food)

ROUND TWO - Fall

2A. Amount of food collected (in lbs.) __________________

2B. Number of pack members_____ x 450 lbs. per member = __________

(this is the number of pounds needed for all pack members to survive)

2C. 2A minus 2B plus 1D (from cache above) = _____________

If 2C is a positive number, put that number in your "cache," and you can use it on future rounds. If 2C is a negative number, put a 0 in cache, and you lose one pack member if it is -1 to -450 lbs., two pack members if it is -451 to -900 lbs. and so on.

2D. **Cache:** ______________

(buried food)

Pack Food Budget

PAGE 2

ROUND THREE - Winter

3A. Amount of food collected (in lbs.) ___________________________

3B. Number of pack members_____ x 450 lbs. per member = __________

(this is the number of pounds needed for all pack members to survive)

3C. 3A minus 3B plus 2D = __________________

If 3C is a positive number, put that number in your "cache," and you can use it on future rounds. If 3C is a negative number, put 0 in your cache, and you lose one pack member if it is -1 to -450 lbs., two pack members if it is -451 to -900 lbs. and so on.

3D. **Cache:** _______________

(buried food)

ROUND FOUR - Spring

4A. Amount of food collected (in lbs.) ___________________________

4B. Number of pack members_____ x 450 lbs. per member = __________

(this is the number of pounds needed for all pack members to survive)

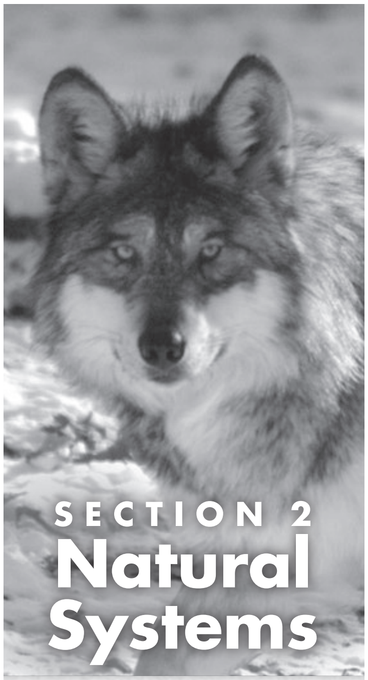
4C. 4A minus 4B plus 3D = __________________

If 4C is a positive number, put that number in your "cache," and you can use it on future rounds. If 3C is a negative number, put 0 in your cache, and you lose one pack member if it is -1 to -450 lbs., two pack members if it is -451 to -900 lbs. and so on.

4D. **Cache:** _______________

(buried food)

At this point, your pack can trade in 100 pounds of food and a den card to receive a "pup" (recycled wolf who had previously died).



Jacquelyn Fallon

Subjects:

biology, geography, mathematics

Approximate lesson time:

20 minutes

Materials:

charts (make into overheads), data tables

Island of Gray Wolves

Using Isle Royale as a case study, students analyze predator-prey relationships with charts and a food web.

STUDENT OBJECTIVES:

At the end of this unit, the student should be able to:

1. Describe an example of island biogeography.
2. Build a food web using Isle Royale animals.
3. Infer the effects of isolation on resident species.
4. Identify the impact that wolves have on moose population dynamics.

VOCABULARY:

island biogeography • overbrowsing

TEACHER BACKGROUND:

What is an island?

An island is an isolated body of land. Many types of islands exist on the earth. For example, an "island" could also be a forested area within a city, or an alpine meadow surrounded by mountains and forests on all sides. Island biogeography is the study of the distribution and population flux of animals and plants in any one of these isolated ecosystems.

What is Isle Royale?

Isle Royale is a group of islands located 15 miles from the north shore of Lake Superior. Isle Royale is also a national park. It consists of more than 400 islands totaling 133,782 acres of land, with 405,500 acres of water within park boundaries. Average Lake Superior water temperature is 40°F, bringing on hypothermia or death in a matter of minutes to those immersed in it. Crashing surf, rocky shores and cold water pose a formidable challenge to island access. More than 70 deaths in ten named shipwrecks have occurred on or near the island.

Wildlife on Isle Royale

In spite of all the challenges of survival, different forms of life have made it to the island. Many bird species have made the c rossing to the island, although winds and strong air currents probably discourage any number of birds on any given day. Mammals comprise an interesting collection of creatures inhabiting the islands. There are at least 31 mammal species living on the north shore of Lake Superior, but only about 14 mammal species living on the Isle Royale islands. These mammals include deer, mice, beavers, red foxes, four species of bats, mink, river otters, short-tailed weasels, snowshoe hare, red squirrels, moose, and wolves.

Wolves were first observed on the island in 1949, and moose arrived somewhere around 1900. At what point in history the other 12 mammal species arrived is still a mystery. Some animals used to live on Isle Royale but no longer do. These mammals include lynx (previous to 1930s), coyotes (arrived in the 1940s, gone by 1949), woodland caribou (last seen 1927), eastern chipmunks and striped skunks (both last seen in 1977), marten (disappeared early in 20th century), and red-backed voles (were reported in the 1800s). House mice and Norway rats were also present on the island at some point, introduced no doubt by humans, but did not persist.

How did they get there?

Perhaps many species wandered to the island from the mainland over frozen lake ice. Wolves, foxes, and otters have all been seen on Lake Superior ice. However, there is no reliable information as to exactly how the animals on Isle Royale did arrive. Full ice bridges connecting the island to the mainland require extremely cold, calm winters and are very rare.

It is believed that there are only two possible ways moose could have arrived on Isle Royale: walking over ice or swimming. In two documented cases of moose swimming in Lake Superior, one recorded a moose that was first spotted several miles off the shore of the island. The moose completed the swim but lay on the shoreline for a long time afterwards. The other case was a moose seen by a boat captain swimming far into Lake Superior. It is not known for certain that moose swam to the islands, but moose seem to be very afraid of walking on ice, and thus it is highly unlikely that they would cross an ice bridge. Rumors of humans introducing moose to the island in the early 1900s remain unsubstantiated. The real truth remains a mystery.

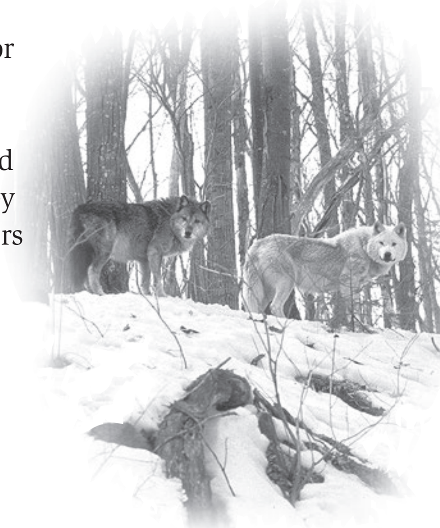
Which mammals never arrived and why?

Most of the mainland mammals have not been successful in reaching the islands. Deer may have dispersed to the island by attempting the swim; however, many die of hypothermia and exhaustion, with their bones washing up on the shores of the islands. Likewise, porcupine skeletons have been found in beach detritus, perhaps also from an attempted swim. Even though black bears are good swimmers, they are also missing from the island.

Other common animals who have not colonized the islands include northern flying squirrels, woodchucks, three species of voles, five species of shrews, star-nosed moles, least weasels, fishers, lemmings, two species of mice, and raccoons.

How hard is it to live there?

Living in an island ecosystem puts a great deal of pressure on all species. Perhaps the most important pressure comes from overbrowsing by moose, which greatly affects the vegetative habitat



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Form and Function

Science as Inquiry

Abilities necessary to do scientific inquiry

Understanding about scientific inquiry

Life Science (5–8)

Structure and function in living systems

Regulation and behavior

Population and ecosystems

For more correlations, please see Appendix IV.

of all the creatures. The isolation also puts pressures on animals, as they must adapt to limited resources.

Moose and beavers inhabiting the same areas may be in conflict over food. Beavers often cut large diameter trees near their ponds. This may stimulate active regrowth of smaller trees, which moose will be attracted to. The intense browsing (eating) may prevent hardwoods from ever reaching the size preferred by beavers.

Mammal Species on Isle Royale:

gray wolf
moose
beaver
snowshoe hare
red fox
red squirrel
deer mouse
short-tailed weasel
mink
otter
lynx
muskrat
little brown bat
Keen myotis (bat)
big brown bat
red bat

How do moose impact Isle Royale's natural system?

The effect that moose have on the ecosystem and its vegetation is enormous. When moose arrived on the islands, there were few or no predators and an abundance of food; thus, their population expanded rapidly (see enclosed chart and data table for actual numbers). Their food supply became over-browsed, and the population went into a serious decline. Several large forest fires in 1936 and 1948 resulted in forest regeneration (especially in birch and aspen) in some areas, and the population began to recover.

How does vegetation impact moose survival?

The amount of vegetation present determines how many moose survive (carrying capacity) and determines in part the moose's susceptibility to predation as well as their birth rates. Limited vegetation causes weak moose to become weaker and produce smaller, weaker offspring. Vegetation studies measure the long-term effect moose may have on the plant communities. Researchers fence in plots of land to keep moose out and study how the vegetation differs. In these studies, it has been found that more than 89 percent of the vegetation is browsed adjacent to the control plots, demonstrating the heavy impact moose have on the vegetation.

How did the arrival of wolves impact moose population?

Arrival of wolves in the 1940s appeared to stabilize the moose population numbers well below what the vegetation on the island could support. At first, it was thought that predators or pathogens were instrumental in limiting the moose population, but more recent research indicates that vegetation plays the biggest role in moose population dynamics. The amount of vegetation available in winter depends largely on snow depth; therefore, weather also plays a significant role in moose survival. Deep snow makes food inaccessible and travel difficult for moose, making them more susceptible to predation by wolves. Wolves tend to cull young and old moose from the population.

Humans on Isle Royale

Humans have both visited and lived on Isle Royale for centuries. Native peoples used the island waters for fishing and mined copper from the hillsides. Early

European settlers began visiting the island on steamships and eventually joined the fishing industry. Today the island is reserved for wilderness camping and biological research. People are allowed to visit the island during the summer months only; winter is largely absent of human presence.

Biologists have been fortunate to use one of the greatest naturally isolated laboratories to study wolf and moose populations on Isle Royale. The wolf-moose study is the longest wolf-prey study anywhere in the world.

ACTIVITIES:

Using Isle Royale as a case study, students will examine several aspects of the interrelationships existing there.

1. Conduct research on the types of mammals found on Isle Royale versus the north shore habitat of Lake Superior (the resources below are a good place to start).
2. Have students determine what species are available in each ecosystem, and construct a food web based on those animals.
3. Examine the enclosed charts. Begin with the moose population chart before the colonization of wolves on the island. Instruct students to analyze the chart and cite reasons for the tremendous spike in the moose population, and for a small rebound in moose population numbers later on.
4. Next, examine the chart of the moose population after the arrival of wolves. Direct students to come up with ways wolves may control a population of animals, such as by culling young and old (Note: Moose populations fluctuated before the arrival of wolves. The declining moose population from 1928–43 was probably due to a lack of food, as moose overgrazed plants and trees on the island and then starved to death. Severe winters can also cause a drop in moose populations.)
5. Looking at the wolf population chart, have students determine possible factors for the rapid growth and rapid decrease of the wolf population. Answers may include an initial abundance of food, food scarcity and other factors such as disease.
6. Students may determine at least two factors in population control of a species based on the Isle Royale study.

ASSESSMENT:

Each student should be able to list factors affecting the survival of populations of any given animal. These may include isolation, disease and food availability. A student should also be able to weave these factors together to form a more complex picture of predator impacts on prey and prey impacts on habitat.

EXTENSIONS:

Students may use the data table of moose and wolf populations from Isle Royale to create graphs for discussion. Simple computer graphing programs may be helpful.

Additional Resources:

Durward Allen. Wolves of Minong. *Ann Arbor: University of Michigan Press, 1993.*

Rolf Peterson. The Wolves of Isle Royale: A Broken Balance. *Minoqua, WI: Willow Creek Press, Minoqua, 1995.*

Napier Shelton. Superior Wilderness: Isle Royale National Park. *Houghton, MI: Isle Royale Natural History Association, 1997.*

Web sites:

Isle Royale National Park: www.nps.gov/isro

Isle Royale Natural History Association: www.irnha.org

Background Information and Questions

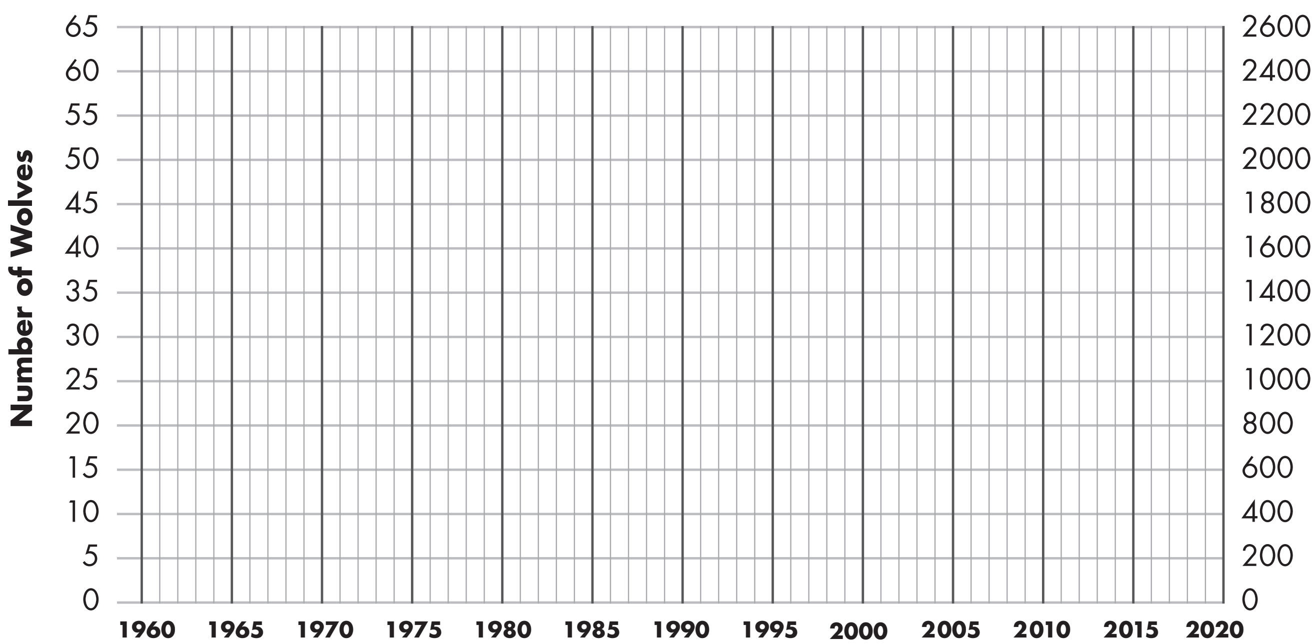
1. In 1981–82, canine parvovirus entered the wolf population (probably carried onto the island by human visitors).
   Mark that spot with the word "virus" on your graph.
   - What effect did this virus, which affects wolf pups, have on the wolf population on the island?
2. In 1996, Isle Royale experienced a severe winter. Mark that "severe winter" on your graph.
   - What effect did that winter have on moose populations?
   - Was the wolf population affected in the same way? Why or why not?
   - What long-term effect could the change in moose population have on the wolf population? Give reasons for your answers.
   - Identify at least two other severe winters based on your graph.
3. Predict probable wolf and moose populations for the future. Give reasons for your answers.

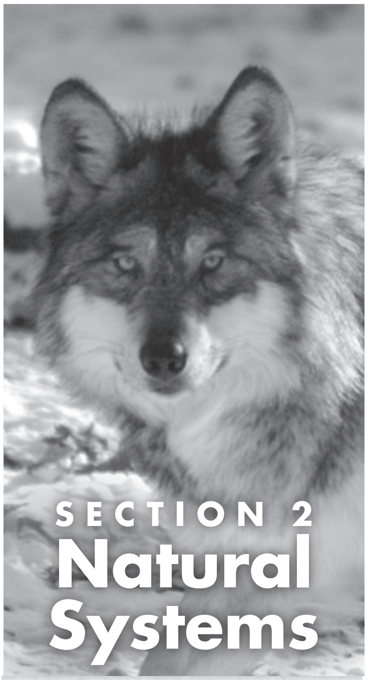
WOLF AND MOOSE POPULATIONS ON ISLE ROYALE

(data from 1960 on is from annual scientific monitoring;
data from before 1960 is from sporadic monitoring and extrapolation)

Year	Wolves	Moose
(estimated data)		
1915	0	200
1925	0	1900
1928	0	5000
1935	0	600
1945	0	500
1955	10	450
(actual data)		
1960	22	637
1961	22	639
1962	23	668
1963	20	717
1964	26	727
1965	28	773
1966	26	898
1967	22	1039
1968	22	1299
1969	17	1348
1970	18	1522
1971	20	1583
1972	23	1507
1973	24	1634
1974	31	1478
1975	41	1462
1976	44	1277
1977	34	1055
1978	40	1072
1979	43	939
1980	50	861
1981	30	797
1982	14	765
1983	23	783
1984	24	813
1985	22	1100
1986	20	1025
1987	16	1380
1988	12	1653
1989	12	1397
1990	14	1250
1991	12	1313
1992	12	1590
1993	13	1879
1994	17	1770
1995	17	2422
1996	22	1163
1997	24	500
1998	14	699
1999	20	750
2000	29	850
2001	19	900
2002	17	1100
2003	19	900
2004	29	750
2005	30	540
2006	30	450
2007	21	385
2008	23	650
2009	24	530
2010	19	510
2011	16	515
2012	9	750
2013	8	975
2014	9	1050
2015	3	1250
2016	2	1300
2017	2	1600
2018	2	1475

Source: Earthwatch Moose and Wolves Curriculum, and Dr. Rolf Peterson





Jacquelyn Fallon

Subjects:

science, biology, sociology, mathematics, reading

Approximate lesson time:

2 hours

Materials:

copies of case studies, paper and pencil

Biodiversity Case Studies

Students analyze case studies in natural systems to illustrate the complexities of biodiversity.

STUDENT OBJECTIVES:

At the end of this lesson, students will be able to:

1. Define *biodiversity* and provide real-world examples.
2. Outline changes that took place in an ecosystem when populations of a species fluctuated.
3. Assess the role humans have taken in altering biodiversity intentionally or nonintentionally.
4. Evaluate the importance of biodiversity from differing perspectives.

VOCABULARY:

biodiversity • predator • prey • carnivore • omnivore • scavenger • producer • consumer • decomposer • ecosystem • natural system

TEACHER BACKGROUND:

This activity gives students real-life scenarios showing the importance of biodiversity in natural ecosystems. For example, a native prairie with 200 species of grasses and forbs (wildflowers) is a diverse ecosystem; a cornfield with one species (corn) and a half dozen weeds is not a diverse ecosystem. More animals will live in a wild native prairie than in a cornfield because a wider variety of food and shelter is available to suit the animals.

What is biodiversity?

The term *biodiversity* is short for biological diversity. This topic examines all living organisms, species and populations on earth. It also includes the genetic variation among categories, and all their biological communities and ecosystems. It also refers to the interconnectedness of genes, species and ecosystems and their interactions with the environment. Usually, scientists refer to three levels of biodiversity: genetic, species and ecosystem diversity. In this lesson we explore species and ecosystem diversity.

Species diversity is all the differences within and between populations of species. Ecosystem diversity is all the different habitats and biological communities on the earth and the variations among them.

What threatens biodiversity?

Species are becoming extinct at the fastest rate known in geological history, and most of these extinctions have been tied to human activity. Habitat loss due to human activity and population growth is a major cause of the loss of species and ecosystems. Alterations of ecosystems, introduction of non-native species and overhunting can also lead to a loss of biodiversity.

Why is biodiversity important?

The Ecological Society of America is an organization dedicated to preserving biodiversity. They state the following:

Diversity breeds diversity. A diverse array of living organisms allows other organisms to take advantage of the resources provided. For example, trees provide habitat and nutrients for birds, insects, other plants and animals, fungi, and microbes.

The diversity of life is not only important biologically, but it also enriches the quality of our lives in ways that are not easy to quantify. Humans have always depended on the Earth's biodiversity for food, shelter, and health. But many people also believe that biodiversity is intrinsically valuable and is important for our emotional, psychological, and spiritual well-being.

Biodiversity also supplies indirect services to humans that are often taken for granted. These include drinkable water, clean air, and fertile soils. The loss of populations, species, or groups of species from an ecosystem can upset its normal function and disrupt these ecological services. Recent declines in honeybee populations may result in a loss of pollination services for fruit crops and flowers.

The Earth's biodiversity contributes to the productivity of natural and agricultural systems. Insects, bats, birds, and other animals serve as pollinators. Parasites and predators can act as natural pest controls. Various organisms are responsible for recycling organic materials and maintaining the productivity of soil.

Ecologists conduct research to better understand biodiversity, quantify its loss, and develop strategies for conserving and using it. Much is still unknown about what species exist and where, and the relationships among them. By inventorying and monitoring biodiversity, ecologists study species abundance, functions, interactions, and importance to maintaining or enhancing the quality of human life.

Information taken from

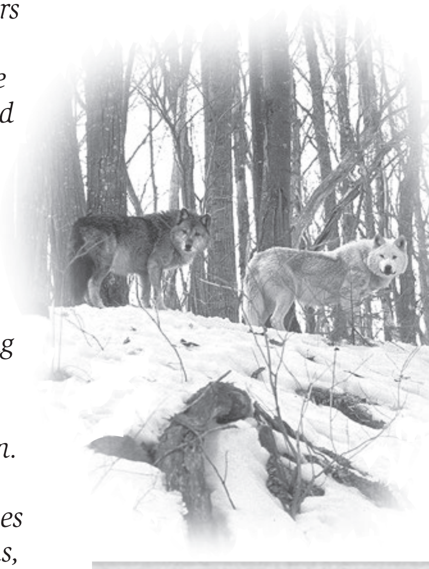
http://esa.sdsc.edu/biodiv2.htm, the Ecological Society of America, 1707 H St., NW, Suite 400, Washington, DC 20006, Tel:202-833-8773.

ACTIVITIES:

A. Share the story below to arouse students' curiosity.

CRISIS ON THE KAIBAB

The Kaibab Plateau is a semi-arid region located near the north rim of the Grand Canyon. In 1906, mule deer, mountain lions, wolves and coyotes lived there in a naturally functioning ecosystem. Also living there were about 200,000 sheep. That year, President Theodore Roosevelt declared the Kaibab Forest a national game reserve, so bounty hunters removed all the predators to prevent their reducing the mule deer population. Most of the sheep were moved elsewhere so the mule deer could feed on the grasses and shrubs without competition.



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National Science Education Standards

Unifying Concepts and Processes

Systems, order, and organization

Evidence, models, and explanation

Change, constancy, and measurement

Evolution and equilibrium

Science as Inquiry

Abilities necessary to do scientific inquiry

Understanding about scientific inquiry

Life Science (5–8)

Structure and function in living systems

Reproduction and heredity

Regulation and behavior

Population and ecosystems

Diversity and adaptations of organisms

For more correlations, please see Appendix IV.

Without predation and competition, the mule deer population exploded, growing from 4,000 in 1906 to more than 100,000 around 1924. The deer ate every blade of grass, leaf, and shrub in sight.

In the late 1920s an estimated 60,000 mule deer starved to death during the winter or died of disease. The deer population continued to decline until the early 1940s when the population returned to levels near that of 1906.

B. Ask students:
- What caused the mule deer population to increase?
- Why did it eventually decrease?

C. Depending on the age level of students, review some of the basic ecological principles of food chains and nutrient recycling. Review or brainstorm what types of organisms make up producers, consumers and decomposers. A quick overview of carnivores, herbivores, omnivores, scavengers and predator-prey relationships may also be helpful.

D. Case Studies
1. Divide students into small groups.
2. Define the term *biodiversity.* This is a large and complex concept for students to grasp. Try describing biodiversity in terms of organisms found in your local or regional area to provide students with something concrete and familiar. For example, describe biodiversity in an organic garden or lack of biodiversity (in terms of grass species) on a golf course.
3. Assign each group a "biodiversity case study."
4. Students will read the case study and examine the complexity of species interaction and biodiversity using the following suggestions:
   - Discuss what happens when one species suddenly increases or decreases in number. What is the effect on other species in the ecosystem?
   - What kinds of actions did wildlife managers take to initiate changes?
   - Evaluate the importance of biodiversity from different perspectives: a species with declining numbers, a species with increasing numbers, an exotic (non-native) species, an ecologist, a developer.
   - Diagram the changes or interactions among the species outlined in the case study, or perform a play.

ASSESSMENT:

A. Have each group give a short presentation about the case study examined. Encourage students to be creative!

Ideas for writing assignments

What kinds of natural events could affect biodiversity in the short term and long term (e.g., hurricanes, floods, mudslides, earthquakes, volcanic explosions and meteor collisions)?

Discuss how human habitation has altered wildlife populations over time. What has caused the enormous changes in biodiversity in the past 500 years? What is the correlation between human lifestyle, use of resources, habitat destruction and loss of biodiversity?

Compare and contrast the need for biodiversity from different perspectives: a family of 15 living in poverty using slash-and-burn farming methods in the Brazilian rain forest versus a vegetarian college student from a middle-class family.

Brainstorm three reasons why diversity is disappearing in our ecosystems. What actions can students take that may affect biodiversity in their local area?

How has the role of humans in the development of transportation over the centuries affected biodiversity? For example, look at changes in biodiversity on Hawaii, Australia and Madagascar, and the spread of exotics and non-native species.

Imagine Ebola or a related virus has gone airborne and caused a global epidemic. Ninety percent of humans on the planet perish. What kind of effect would this have on biodiversity? Paint a picture of how the world would look 100 years after the event.

How has global climate change affected biodiversity in the past? Hypothesize on the effects of global warming in the near future. How might biodiversity and the location of ecological zones be altered?

EXTENSIONS:

1. Instruct students to find other wildlife case studies from your state wildlife agency.

What do these case studies say about the effects of biodiversity on animal populations and ecosystems?

Do animal populations always follow the patterns we expect them to follow? Why or why not?

What can the trends we see in these wildlife case studies teach us about how we should manage our wildlife populations?

2. Defend or refute the idea of introducing wolves or grizzlies in the West based on information learned from these case studies.

> *We consider species to be like a brick in the foundation of a building. You can probably lose one or two or a dozen bricks and still have a standing house. But by the time you've lost 20 percent of species, you're going to destabilize the entire structure. That's the way ecosystems work.*
>
> *Donald Falk,*
> Christian Science Monitor,
> *26 May 1989*

Lynn and Donna Rogers

BIODIVERSITY CASE STUDY

Starfish Rule the (Tide)pool

Researchers are finding that not all species are equal in their effect on an ecosystem. Top predators can sometimes have an especially powerful impact on a habitat. One of the first researchers to demonstrate this principle was Robert Paine from the University of Washington. In a 1966 study, Paine removed a starfish *(Piaster ochracues)* from an experimental area in the intertidal (or tidepool) regions of the Pacific seashore. Intertidal areas are the areas between the high and low tide marks on the shore. They are underwater during high tide and open to the air during low tide.

When Paine removed the predatory starfish, the barnacles and mussels that starfish fed on increased in number and outcompeted other, more slow-growing or slow-reproducing species. It appears that the starfish, by feeding on barnacles and mussels, clears out portions of the intertidal area. This disruption provides space for other species. The number of species in each study area dropped by almost half, from 15 species to 8.

Paine studied the effect of removing other predators from his enclosures, but none of those removals had results comparable to the starfish removal. In fact, the removal of the starfish affected the varieties and population densities of all other species in the area, even species that starfish did not prey upon. The starfish seems to govern the biological diversity of the entire ecosystem.

Paine is quick to point out that the reason he terms starfish a predatory “keystone species” is because its impact on the ecosystem is much greater than its size would suggest. Obviously large kelp, old-growth trees and huge expanses of prairie grass have a large impact on a habitat and the species that live there, but that impact is equal to these plants’ relative biomass. For that reason, he would not consider them “keystone species.”

Sources:

Mills, L. Scott, Michael E. Soulé, and Daniel F. Doak. 1993. The keystone-species concept in ecology and conservation. BioScience *43, 4: 219.*

Paine, R. T. 1966. Food web complexity and species diversity. American Naturalist *100: 65–75.*

Paine, R. T. 1980. Food webs: Linkage, interaction strength and community infrastructure.
Journal of Animal Ecology *49: 667–85.*

BIODIVERSITY CASE STUDY

Coyotes in Southern California

In 1999, two researchers (K. R.Crooks and M. E. Soulé) determined that large predators like coyotes have a major impact on the diversity and population numbers of songbirds in patches of sage-scrub habitat in southern California. Larger natural areas that had coyotes had more songbirds and more diversity of bird species.

Coyotes had this impact by preying upon "mesopredators" (medium-sized predators) like domestic cats, striped skunks, raccoons, gray foxes and opossums. In the absence of coyotes, the mesopredators increased in abundance and fed heavily on the birds. That increased predation led to a drop in native bird populations, often to the point where local extinctions occurred or were inevitable. Thus, the fate of the birds is driven largely by the survival of a predator two trophic (food web) levels above it. If the factors that limit a mesopredator population disappear, that population may experience what is called ecological release, reproducing quickly and expanding their population.

Crooks and Soulé discovered that larger patches of wild land have a positive effect on coyote and bird populations. Cats become dinner more often in larger wild areas that are home to coyotes. Coyotes have a negative effect on mesopredators (more coyotes = fewer cats).

Mesopredators (such as cats) have a negative effect on birds, which means that the presence of cats causes bird numbers to decline. Cats predate heavily on bird populations because they are recreational hunters. Human owners feed cats and then let them hunt in nearby wild areas, permitting many more predators to exist in the ecosystem than the carrying capacity the scrublands can support. A scrubland habitat patch of about 20 hectares could easily have 35 cats from surrounding housing developments. By comparison, the same property could naturally support only one or two pairs of native foxes, a natural mesopredator.

The longer that a wild area has been isolated from other wild areas by suburban development, the worse the decline of bird populations. These factors combine to spell doom for native scrubland birds such as Western Scrub-Jays, California Gnatcatchers, California Quail, Bewick's Wrens and Wrentits in small, isolated scrublands that have high numbers of cats and other mesopredators.

The presence of coyotes seems to keep mesopredators out of wild areas. Perhaps cats instinctively avoid areas where they are not the top predator. Coyotes also kill and eat mesopredators. In the Crooks and Soulé study, about 21 percent of coyote scats contained cat remains, and coyotes killed 25 percent of radio-collared cats.

Sources:

Crooks, K. R., and M. E. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature *400: 563–66.*

Krebs, C. J. 1994. Ecology: The Experimental Analysis of Distribution and Abundance. *4th ed. Menlo Park, CA: Addison-Wesley.*

Saether, B.-E. 1999. Top dogs maintain diversity. Nature *400: 510–11.*

Schmidt, K. A. 2003. Mesopredator effects on songbirds. Conservation Biology *17, 4: 1141–50.*

BIODIVERSITY CASE STUDY

Lyme Disease Outbreak

Maintaining ecosystem health may improve human health as well. In the northeastern United States, the outbreak of Lyme disease has led researchers to conclude that forest fragmentation and the loss of predators for white-footed mice and white-tailed deer (the main carriers of the disease and the ticks who transmit it) have resulted in population explosions for deer, mice and deer ticks. As humans are increasingly suburbanizing forest areas and coming in close contact with both deer and mice, they are much more likely to be bitten by infected deer ticks and to contract the disease.

Lyme disease was named in 1977 when doctors identified an arthritis-like condition in children near Lyme, Connecticut. Since that time the disease has spread to the Midwest. Lyme disease is caused by spirochete *(Borrelia burgdorferi)*, a bacterium transmitted to humans by the bite of infected ticks. Typical symptoms include fever, headache, fatigue and a characteristic skin rash.

It seems likely that Lyme disease has persisted for a long period of time in wildlife populations, but because of natural predator and forest habitat population controls, deer and mice populations did not come in such close proximity to human communities. The population density of white-footed deer mice and deer is high in forest fragments, where predator populations in general are reduced by humans. Lyme disease risk is 10 times greater in small forest fragments than larger fragments. Small forest fragments near human dwellings and activity carry the highest densities of mice, deer and infected ticks.

Over the past 50 years, the human population and suburban development in the highly populated northeastern states have moved humans in much closer proximity to deer and mouse populations while at the same time fragmenting second-growth forests in the region. Since deer and mice thrive on forest edges and many deer and mouse predators (wolves, owls, weasels, foxes) survive better in large forested regions, humans may have created the perfect conditions for an outbreak of Lyme disease.

Sources:

Koren, H. S., and D. Crawford-Brown. 2004. A framework for the integration of ecosystem and human health in public policy: Two case studies with infectious agents. Environmental Research *95: 92–105.*

Ostfeld, R. S., C. G. Jones, and J. O. Wolff. 1996. Of mice and mast. BioScience *46: 323–30.*

Ostfeld, R. S., and F. Keesing. 2000. Biodiversity and disease risk: The case of Lyme disease. Conservation Biology *14: 722–28.*

BIODIVERSITY CASE STUDY

There "Otter" Be Kelp Forests

Where we have sea otters, we have ocean kelp forests. Kelp is a long, algal organism that lives in near-shore ocean, growing up to 165 feet tall. Many other species live in the thick kelp areas, called "forests," comparable to life in a coral reef.

When the sea otters disappear, due to trapping, disease or killer whale predation, kelp forests shrink or disappear. This seems to happen because sea otters eat sea urchins, aquatic organisms related to starfish that look like small, spiky purple hedgehogs. Without predation by otters, sea urchins will eat the kelp until it is gone, creating an "urchin barrens" on the sea floor.

Unfortunately, when the yellow-brown rubbery kelp disappear, other organisms are also affected. Kelp provide shelter for spawning herring and habitat for many other organisms and increase water clarity and color.

When biologists release new sea otters into areas where they had been extirpated, they immediately begin feeding on sea urchins, and the kelp forests begin growing back. In a study in Alaska, researchers determined that the sea urchin population declined by 50 percent in the Aleutian Islands and by nearly 100 percent in southeast Alaska after sea otters moved in to previously unoccupied habitats. In some areas, kelp grew dramatically when the otters returned.

Because of the direct relationship that seems to exist between sea otters and the kelp forest ecosystem, researchers term the sea otter a "keystone species," meaning that it is a species that is critical to ecosystem to survival.

Source:

Estes, James A., and David O. Duggins. 1995. Sea otters and kelp forests in Alaska: Generality and variation in a community ecological paradigm. Ecological Monographs *65, 1: 75–100.*

BIODIVERSITY CASE STUDY

Yellowstone National Park

The return of the gray wolf to Yellowstone National Park has caused a cascade of effects that scientists are only beginning to understand. Wolves were exterminated from the park by the early 1930s because they were believed to be a threat to humans and a menace to the ecosystem. Sentiments changed, and in 1995 and 1996 wolves were reintroduced into Yellowstone as well as central Idaho.

In the time since the wolf's return to Yellowstone, biologists have been monitoring the plants' and animals' response to wolves. Preliminary results from scientific studies reveal that changes are occurring. One study showed that elk—the wolf's primary prey—changed their browsing behavior after wolves were reintroduced to the park. Prior to the return of wolves, high numbers of elk grazed heavily on trees and other plants in the river valleys. With wolves present, the elk must now be more vigilant to avoid predation by wolves. When elk move about the ecosystem more actively, the trees in the river valleys are not grazed as heavily and can regenerate more readily. Scientists have noted that aspen, willow and cottonwood trees all are growing taller and spreading more widely in these areas. With more hardwood trees available, beavers have more food and build dams that create ponds. With expanded riparian areas, a wider range of plants and animals find homes, including songbirds and trout.

Other changes are being observed as well. When wolves kill elk, they often leave food behind for scavengers such as ravens, grizzly bears, magpies, wolverines, eagles and various beetle species, helping those populations to grow strong. Wolves reduce coyote numbers because the two species compete for food. Fewer coyotes mean that red foxes, hawks and eagles have less competition for smaller prey such as ground squirrels and gophers.

Ecological relationships are complex and difficult to document. While many changes in Yellowstone's ecosystem have been documented since wolves arrived, it is impossible—and inappropriate—to attribute all the changes to wolves. Drought, extreme winter weather and even human activity affect the ecosystem. Even if biologists could document all the aspects of such complex cause-and-effect interactions, the story is still unfolding. All the animals and plants in the Yellowstone ecosystem will continue to change and adapt in response to many factors, including each other, for many years to come. Fifty or 100 years from now we may begin to have a clearer picture of the true impact of the wolf's reintroduction to Yellowstone.

Sources:

Ripple, W. J., and R. L. Beschta. 2003. Wolf reintroduction, predation risk, and cottonwood recovery in Yellowstone National Park. Forest Ecology and Management *184: 299–313.*

Smith, D. W., R. O. Peterson, and D. B. Houston. 2003. Yellowstone After Wolves. BioScience *53:330–40.*

Ripple Effect?

Students draw a conclusion about the wolf's effect on its ecosystem by building a logical argument.

STUDENT OBJECTIVES:

At the end of this lesson, the student should be able to

1. Construct pieces of biological evidence into a logical sequence to build a defensible conclusion.
2. Infer the wolf's influence on biodiversity.

VOCABULARY:

biodiversity • ecosystem • scavenger • prey • predator • mesocarnivore

TEACHER BACKGROUND:

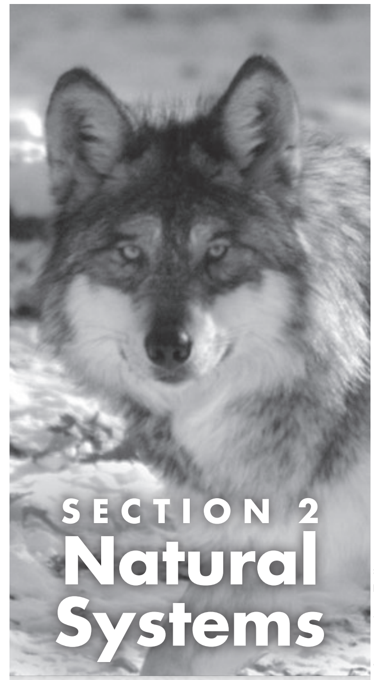
Most scientists agree that wolves constitute a major ecological force in ecosystems where they are present. Like any species, wolves influence other species and ecological processes. But does the presence of the wolf in an ecosystem have an effect on neotropical migratory songbirds? How can we know?

Research continues to be conducted on wolf behavior, prey selection, the influence of prey on ecosystems, and the correlations between and among all ecosystem components. While the primary impact of one species on another (wolves killing prey) is comparatively easy to measure, the domino effect of multiple species affecting each other over time in varying weather conditions makes identifying secondary and tertiary effects more difficult to measure and therefore less certain.

Proponents of wolf recovery often argue that wolves benefit their ecosystems. Science can establish that wolves have an impact, but the extent of the impact is largely unproven. In addition, the judgment of whether wolves constitute a positive or negative effect on the ecosystem is a purely human determination.

In this lesson, students are challenged to do the same synthesis work that scientists do. They will assemble scientific claims and evaluate whether a conclusion can be drawn. Before this activity it may be helpful to review with students how components of an ecosystem affect each other.

For example, various studies demonstrate the wolf's influence on prey, such as deer, moose and elk. Other studies measure the influence of deer, moose and elk on vegetation. Yet further studies identify the importance of vegetation for migratory songbird habitat. So, if more wolves mean fewer elk, and if fewer elk mean more vegetation, and more vegetation means more songbirds, then does more wolves mean more songbirds? What if the study on birds was conducted in a



Jacquelyn Fallon

Subjects:

reading, biology

Approximate lesson time:

1 hour

Materials:

a set of evidence cards for each student or group of students different ecosystem than the study on prey? In some cases, research findings may be transferable, but in other cases transferability is limited. Here, students must think like scientists and build a logical argument and identify flaws in logic.

To complete this activity, students will need to understand the concept of biodiversity. Please refer to the “Biodiversity Case Studies” activity on page 46 for further information.

This lesson also refers to the wolf’s influence on a group of animals called “mesocarnivores.” These are medium-size carnivores, including coyotes, marten, fishers, red foxes, river otters, lynx and others whose livelihood usually consists of small prey such as rabbits, hare, insects, mice and other rodents.

ACTIVITY:

1. Pose this question to students: “Wolves have a significant effect on their ecosystems. True or false?” Regardless of student answers, challenge students to defend what *significant* means. How can the wolf’s impact be measured?
2. Arrive at some conclusion about what *significant effect* means. It should involve a total ecosystem perspective. For example, a significant effect could be that wolves cause obvious change at every trophic level. Or the students may choose a more subtle “wolves have a proven influence on at least 10 other ecosystem components.”
3. Challenge students, either individually or in groups, to build a logical argument that defends this conclusion using the scientific evidence provided on pages 57–59. Students should arrange the evidence cards in a logical sequence that builds to the conclusion defined in number 2 above. Suggest that students look for sequences that establish the wolf’s effect on prey, vegetation, scavengers, other large carnivores or mesocarnivores.

Discuss:

- From this information, can you prove that wolves have a significant effect on their ecosystems?
- What limitations are there given that most studies are done in different ecosystems: Minnesota, Yellowstone National Park, Isle Royale and other places?
- What new research is needed to fill in logic gaps?
- Which effects that a wolf has on the ecosystem can be considered “good,” and which are “bad”?
- Compare and contrast the wolf’s effects on the ecosystem with the effects humans have on the environment.

ASSESSMENT:

Students may turn in their logical sequences by transferring the ideas to paper or simply taping the evidence cards to a large piece of paper. Students should articulate why they believe their sequences make sense.

EXTENSIONS:

Another way to understand the evidence cards and demonstrate their relationship to each other is to create a concept map with the cards, arranging them graphically to demonstrate their relationships instead of being limited to linear sequences of cause and effect.

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Population and ecosystems

Diversity and adaptations of organisms

For more correlations, please see Appendix IV.

EVIDENCE CARDS
(cut apart)

When wolves and coyotes are present in the same ecosystem, coyote numbers may be reduced or eliminated due to competition

(Mech 1966, Crabtree and Sheldon 1999).

Wolves have the following effects on the ecosystem: "sanitation effect" by culling of inferior prey individuals, control or limitation of prey numbers, stimulation of prey productivity, increase in food for scavengers, predation on non-prey species

(Mech 1970).

Deep snow conditions over three or more years restrict deer and moose mobility and food intake, thus reducing maternal nutrition. This results in decreased fawn and calf survival in successive years

(Mech, McRoberts et al. 1987).

Mesocarnivores such as coyotes, foxes and wolverines are considered ecologically important because they reduce and may limit some rodents/small mammals

(Buskirk 1999).

Ungulates increase biodiversity by reducing the influence of the dominant plants, thus increasing the diversity of other plants

(Boyce 1998).

When wolves are in the ecosystem, herds of prey tend to have individuals who are healthier because wolves usually kill the older or otherwise weaker individuals

(Mech 1966, Bubenik 1972, Schwartz et al. 1992).

When wolves are in the ecosystem, various prey species may demonstrate "antipredator behavior." They may seek forest cover, may avoid deep snow areas, may hide in terrain more treacherous for wolves

(Singer and Mach 1999).

Depending on the ecosystem, a variety of scavengers may feed on a wolf-killed carcass: brown bears, black bears, coyotes, cougars, red foxes, arctic foxes, lynx, bobcats, wolverines, golden eagles, bald eagles, turkey vultures, gray jays and 400 species of beetles

(various studies).

Historical evidence indicates that after wolves were removed from Yellowstone National Park, fewer new aspen trees began growth

(Ripple and Larson 2000).

As a result of food competition, wolves, bears and cougars sometimes kill each other, which may influence the number and social structure of these predators

(Palomares and Caro 1999).

In deep snow conditions on Isle Royale, moose are less mobile, less able to forage for food, and more vulnerable to wolves

(Peterson and Allen 1974).

When wolves reduce a prey population, they also reduce the total number of prey that would have died every year from other deaths (disease, starvation) and been available for scavengers.

EVIDENCE CARDS
(cut apart)

Wolves reduce coyote numbers

(Ballard et al., chapter 10, in Mech and Boitani 2004).

Ravens benefit from the presence of wolves in the ecosystem by scavenging on wolf kills

(Murie 1944, Mech 1966, Peterson 1977, Carbyn et al. 1993).

Prey live only on vegetation.

Ravens could consume up to 66 percent of the available food on a kill made by a lone wolf

(Promberger 1992).

Without wolves in the ecosystem, coyotes interfere (compete) more with red foxes

(Crabtree and Sheldon 1999, Singer and Mack 1999).

Fir constitutes 60 percent of a moose's diet in winter on Isle Royale

(McLaren and Peterson 1994).

Mesocarnivores probably cause a decrease in ground-nesting birds and other small vertebrates

(Terborgh et al. 1999).

The amount that a fir tree can grow is dependant on how heavily the moose feed on it

(McLaren and Peterson 1994).

Wolves provide a year-round supply of carcasses for scavengers to feed on.

Wolves probably promote scavenging birds: ravens, eagles, jays, chickadees etc.

(Stahler 2000).

Wolves promote scavenging insects, dung beetles etc.

(Sikes 1994).

Ungulates reduce biodiversity by feeding on or eliminating various types of low-growing vegetation

(Wagner 1994).

Brown bears easily take ownership of wolf-killed carcasses

(Murie 1944).

Reduced coyote numbers may lead to increases in the number of other mesocarnivore species

(Buskirk 1999).

When wolves have enough food, they may not interfere with scavengers who are eating from the same kill

(Peterson 1995).

EVIDENCE CARDS
(cut apart)

When wolves reduce prey numbers, then fewer prey remain for competing predators such as cougars, bears and coyotes.

Higher prey numbers lead to a bigger wolf population (Fuller 1989).

Large predators such as cougars, bears and coyotes usually access a shared prey base, thus causing competition.

Good quantity and quality of vegetation bring more and healthier ungulates (W. H. Mautz 1978).

When resources are restricted (e.g., not enough food), competition for limited resources is increased.

Deep snow prevents ungulates from getting a good quantity of good-quality vegetation (Mautz 1978).

Wolves are an important predator on large mammals because they can change numbers of them drastically (Mech and Karns 1977).

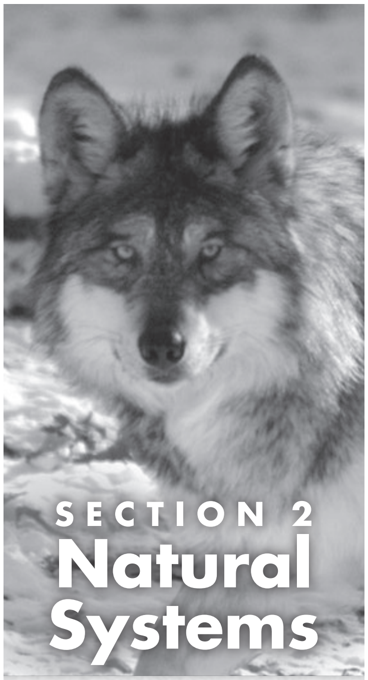
Wolves decrease prey numbers through predation. Those deaths might have occurred from starvation or disease if the wolf had not killed the deer.

Deer population decreases with a colder, deeper snow winter because they have a reduced ability to find food.

Aspen growth increased after wolf restoration in Yellowstone (Ripple et al. 2001).

When species compete for resources, the individuals may change their habitat selection and travel patterns (Connor and Bowers 1987).

Wolves living in packs can eat more meat faster than scavengers such as ravens can eat (Vucetich et al. 2004).



Jacquelyn Fallon

Subjects:

geography, sociology, biology, mathematics

Approximate lesson time:

2 hours

Materials:

overheads of maps, paper and pencil

Mapping a Wolf's World

Students use maps to deduce critical wolf habitat components and make correlations between different factors affecting wolf populations.

STUDENT OBJECTIVES:

At the end of this lesson, students will be able to:

1. Define "limiting factors" and identify what limiting factors may affect wolves in Minnesota.
2. Analyze data through identifying relationships between the wolf and habitat components.
3. Predict how wolf habitat may change in the future and speculate on how this may affect wolf range and the management of the animal.

VOCABULARY:

limiting factors • density • carrying capacity

TEACHER BACKGROUND:

A limiting factor is a component of an animal's habitat (home) that may prevent the animal from increasing its population indefinitely. Many factors determine where an animal can live, such as food availability, appropriate shelter, temperature and snowfall. In this activity, students will look at maps of Minnesota and determine what factors affect where the wolf lives now and where its population may expand in the future. Maps students will examine include the location of food sources, human population densities and habitat type. When an area holds the maximum number of animals that it can sustainably support, we say that it has reached its carrying capacity.

For example, on Isle Royale, there is a limited amount of vegetation on the island. When the moose population exceeds the amount of food that can support all individuals, many moose die of starvation, and the population crashes. The moose exceeded the island's carrying capacity. Since it is impossible for moose to migrate or switch food sources, they starve. The vegetation is a limiting factor for the moose.

A close analysis of potential limiting factors is one way to determine whether an animal can be successful in an area. The enclosed series of Minnesota maps will allow the students to discover correlations between a number of different potential limiting factors and the presence of wolves. Understanding how all of these limiting factors affect the wolf will give students a better sense of the complex factors influencing the successful survival of the wolf. By grasping these concepts, students will get a better idea of the challenges facing wildlife managers.

Preparatory Work

You may choose to photocopy the maps in Appendix I onto overhead sheets, then overlap various maps to show the relationships between them. It is also possible to simply compare paper copies of the maps by holding two maps up to the light or visually comparing them side by side.

ACTIVITIES:

1. Divide students into groups of three to four. Place a pair of maps on the overhead. Have the students discuss and answer questions in small groups.
2. NOTE TO TEACHERS: Some maps have been included that have no apparent relevance to wolf populations. Students should be encouraged to hypothesize and use logic to support their answers but also think creatively. Here is a listing of suggested maps to pair with questions to help students make correlations.

A. Maps: **Major Cities in Minnesota** and **Major Highways in Minnesota**

Question: What correlations can you find between these maps?

Extension: Speculate on why the cities are located where they are, using your knowledge of Minnesota geography and history.

B. Maps: **Current Wolf Range** and **Minnesota Population by County**

Question: Do you see any connections between where major cities are located and where wolves live?

Extension: What physical characteristics do cities have that may or may not provide wolves with their basic needs?

C. Maps: **Expansion Range by Contiguous Packs** and **Head of Livestock**

Question: What correlations can you draw between the density of wolves (past and present) and the presence of cows/sheep in the state?

Extension: Do you think that there have been more or less wolf attacks on livestock in the past compared to more recent years? Why?

D. Maps: **Current Wolf Range** and **Turkeys in Minnesota**

Question: What observation can you make between wolf range and turkeys?

Extension: Wild turkeys used to be more common in Minnesota. Do you think that wild turkeys used to be a common food source for wolves? Why or why not? Do you think that wolves had something to do with the turkey population decline?

Lynn and Donna Rogers /www.bearstudy.org

National Science Education Standards

Unifying Concepts and Processes

Systems, order, and organization

Evidence, models, and explanation

Change, constancy, and measurement

Evolution and equilibrium

Science as Inquiry

Abilities necessary to do scientific inquiry

Understanding about scientific inquiry

Life Science (5–8)

Regulation and behavior

Population and ecosystems

For more correlations, please see Appendix IV.

E. Maps: **Current Wolf Range** and **Deer in Minnesota** or **Moose Range**

Question: Do you see any similarities between wolf range and these animals' ranges?

Extension: Deer can often be found in a mixture of forest and open land. When settlers cleared forested land to plant crops, they created more deer habitat. It seems logical that wolves would have followed this food source into new areas. Speculate on why there aren't more wolves in this type of habitat.

F. Maps: **Current Wolf Range** and **Major Vegetation Types (1990s)**

Question: What type of land cover is associated with wolf presence?

Extension: Examine the Native Vegetation map (late 1800s). Speculate on wolf territory in the past: do you think it has increased or decreased? Why?

G. Maps: **Current Wolf Range** and **Annual Precipitation** or **Landforms**

Question: Does precipitation or landforms seem to be limiting factors for wolves?

Extension: Can examining these maps help us understand any facets of wolf population dynamics?

H. Maps: **DNR Management Zones**

Question: Why do you think the DNR has divided the state into two zones with different wolf management plans?

Extension: Who do you think had a stake in deciding this plan? What type of groups might have lobbied for or against this plan? Why?

I. Direct students to look for other correlations on the different maps and ask their own questions.

More questions:

- Why might wolves be living primarily in areas with lower human density?
- Why are there fewer humans where there are fewer roads?
- Do most wolves live in areas where there is high road density (and presumably lots of humans)?
- Is the human population more dense in certain vegetative regions? Why?
- Which directions are wolves expanding in Minnesota? Why?
- Make a list of all the possible limiting factors affecting wolves.
- What factors do not seem to have any effect on wolf populations?
- How might any of these maps have been different in 1800?

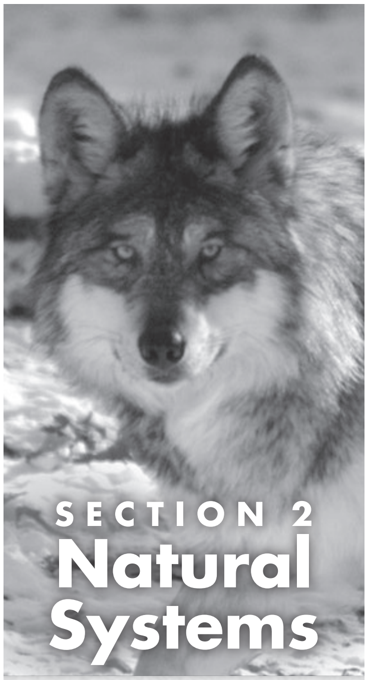
ASSESSMENT:

1. After comparing all the maps, have students decide what parts of the state could reasonably support wolves. Students will need to find a balance between habitat qualities and human presence. Have students sketch their hypothesis onto the blank map of Minnesota.
2. Have students project the following: How might dynamics in the state change in the next 10 years? The next 50 years? Which might affect wolf populations? What problems might arise from these changes? How might this affect wolf populations? What solutions would you propose?

EXTENSIONS:

Tell students to research another species. Collect maps (or draw based on readings) related to this species' habitat needs. Share this information with classmates, younger students or family members.

Serle Chapman



Jacquelyn Fallon

Subjects:

sociology, biology, geography, government, economics

Approximate lesson time:

45 minutes

Materials:

approximately 150 3" x 5" index cards, masking tape

LESS/MORE

Students build a concept map on the wall.

LESSON OBJECTIVES:

At the end of this lesson, students will be able to:

1. Identify at least three other animals, emotions or factors that are intertwined with the presence of the wolf.
2. Predict long-term interactions between the wolf and other components of the human and natural environments.

VOCABULARY:

Make sure that students are familiar with the words on the cards.

TEACHER BACKGROUND:

While most students realize that the wolf has an important relationship with its prey, they may not realize that the wolf is also connected to other elements of the natural and human environments. This activity helps students identify relationships and domino effects that wolves have.

Please note: For the sake of simplicity we are using the word less, *even in cases where* fewer *would be more grammatically correct!*

Preparation:

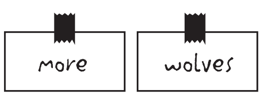
1. Less/More cards: With a thick marker, the teacher should write the word *more* on about 25 index cards and the word *less* on about 25 cards.
2. Impact cards: With a thick marker, the teacher should write the following words on index cards (one word per card):

disease	knowledge
beaver	fossil fuels
death	frustration
open spaces	statistics
starvation	global warming
arguments	water
cars	jobs
forests	clouds
conflict	garbage
meetings	hunting
information	insects
romanticism	gardens
wolves	parasites
deer	power
scavengers	plants
optimism	sun
poaching	flowers
overpopulation	nutrients
money	pollution
independence	decay
property rights	fire
depredation	politics
limitations	scat
public lands	grass
indoctrination	soil
understanding	learning
propaganda	recycling

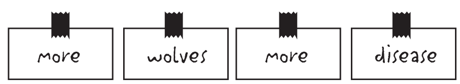
puppies
highways
protection
solutions
moose
empowerment
dialogue
food
control
taxes
trees
unemployment
confusion
research
trust
ecotourism
compromise
freedom
peace
stories
fear
laws
songbirds
chaos
education
humans
wolves
(it may be interesting to have several of these)
money
(it may be interesting to have several of these)
and any other appropriate words.

ACTIVITIES:

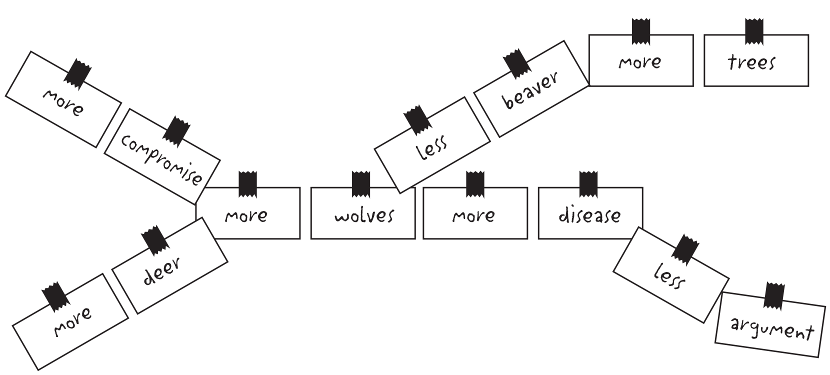
1. Tape a card with the word *more* on the wall or chalkboard. Tape a card with the word *wolves* to its right, as illustrated.

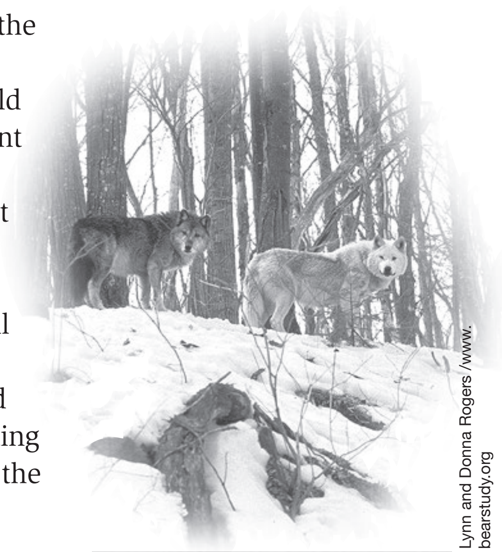


2. Distribute the impact cards so each student has several. Leave the *more* cards and the *less* cards on a table nearby.
3. Ask the students to think about what impact would be caused by "more wolves." Would there be fewer deer? More eco-tourism? More conflict? Less protection? Direct the students to look at the "impact cards" that they have and ask for a volunteer to build a link. For example, if a student has an impact card with the word *disease* on it, the student might tape another *more* card next to the word *wolves* on the wall and add *disease* next to it, as illustrated. The student should explain their rationale for putting up that card. In this example, the student might explain that if there are a lot of wolves, then a disease might easily spread through the wolf population.



4. Students should think about more relationships they can identify and, one at a time, add them to the relationship diagram, as illustrated. Be sure to tell students to explain their answers. If a student does not see a place where their impact word could fit, have other students place their words first, and an opportunity should eventually come up for all of the words. Encourage the students to be creative.





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National Science Education Standards

Unifying Concepts and Processes

Systems, order, and organization

Evidence, models, and explanation

Change, constancy, and measurement

Science as Inquiry

Abilities necessary to do scientific inquiry

Understanding about scientific inquiry

Life Science (5–8)

Structure and function in living systems

Population and ecosystems

Life Science (9–12)

Interdependence of organisms

Matter, energy, and organization in living systems

For more correlations, please see Appendix IV.

5. Students continue this until all the impact cards are used up or the class runs out of time. Instruct students to step back and look at the diagram of relationships.
6. Have the students point out relationships that they would disagree with or explain differently.

Discussion:

1. In what ways does this diagram reflect the real world as you know it?
2. In what ways does this diagram not reflect the real world?
3. What relationships surprise you?
4. In what way is the wolf connected to environmental issues like global warming or waste management?
5. Which elements (or impact cards) cause the most complexity in the diagram?

ASSESSMENT:

1. Tell students to look up the word *synergy* and in small groups discuss how the diagram illustrates this concept.
2. Have students discuss or write a paragraph about how this diagram would be different if they had started with "less wolves" instead of "more wolves."

EXTENSIONS:

Do this activity again, but allow the students to write their own impact words on the index cards.

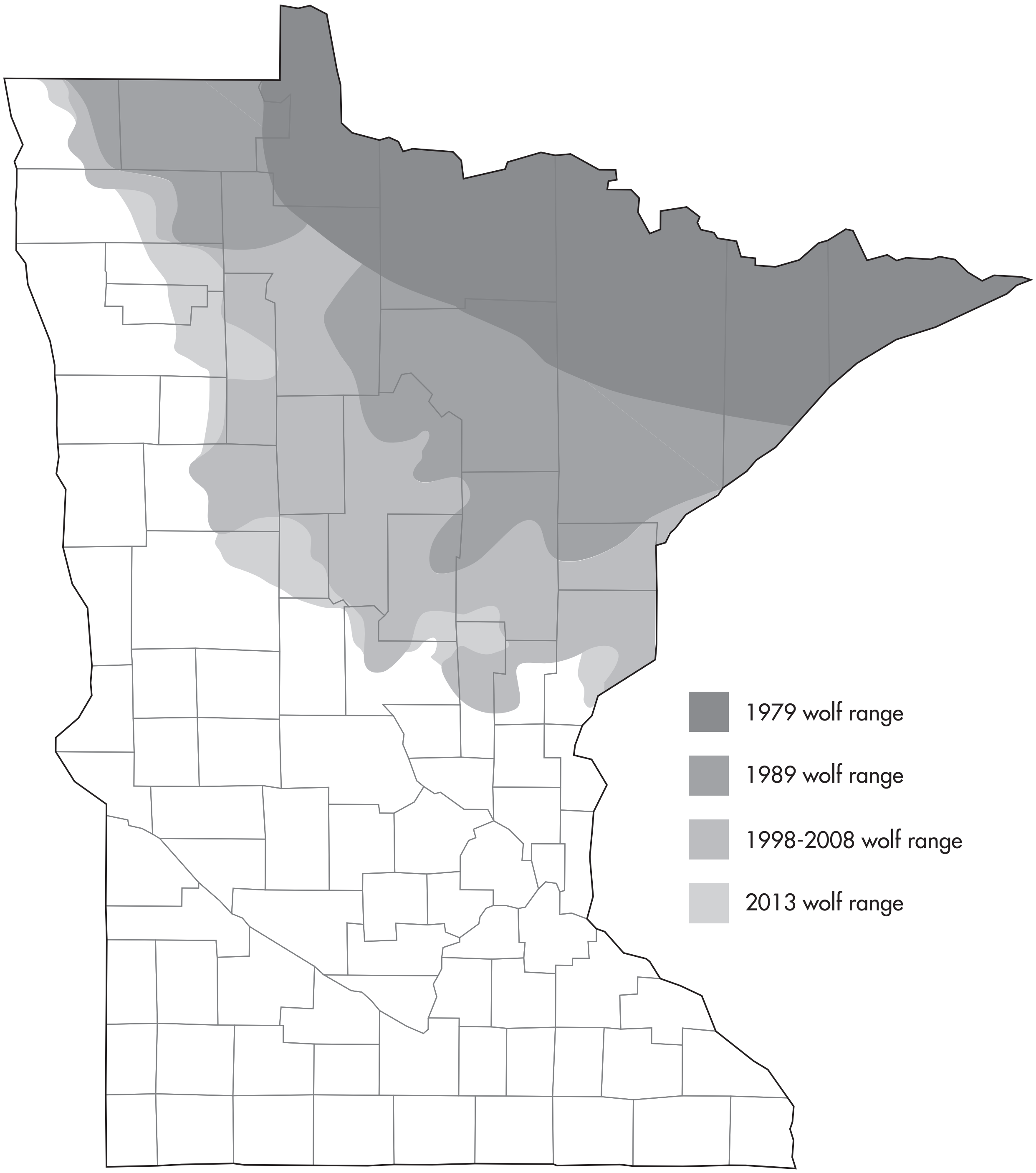
Activity adapted with permission from Population Connection's Counting on People learning kit, www.popultioneducation.org

Patrick Tilbury

APPENDIX I

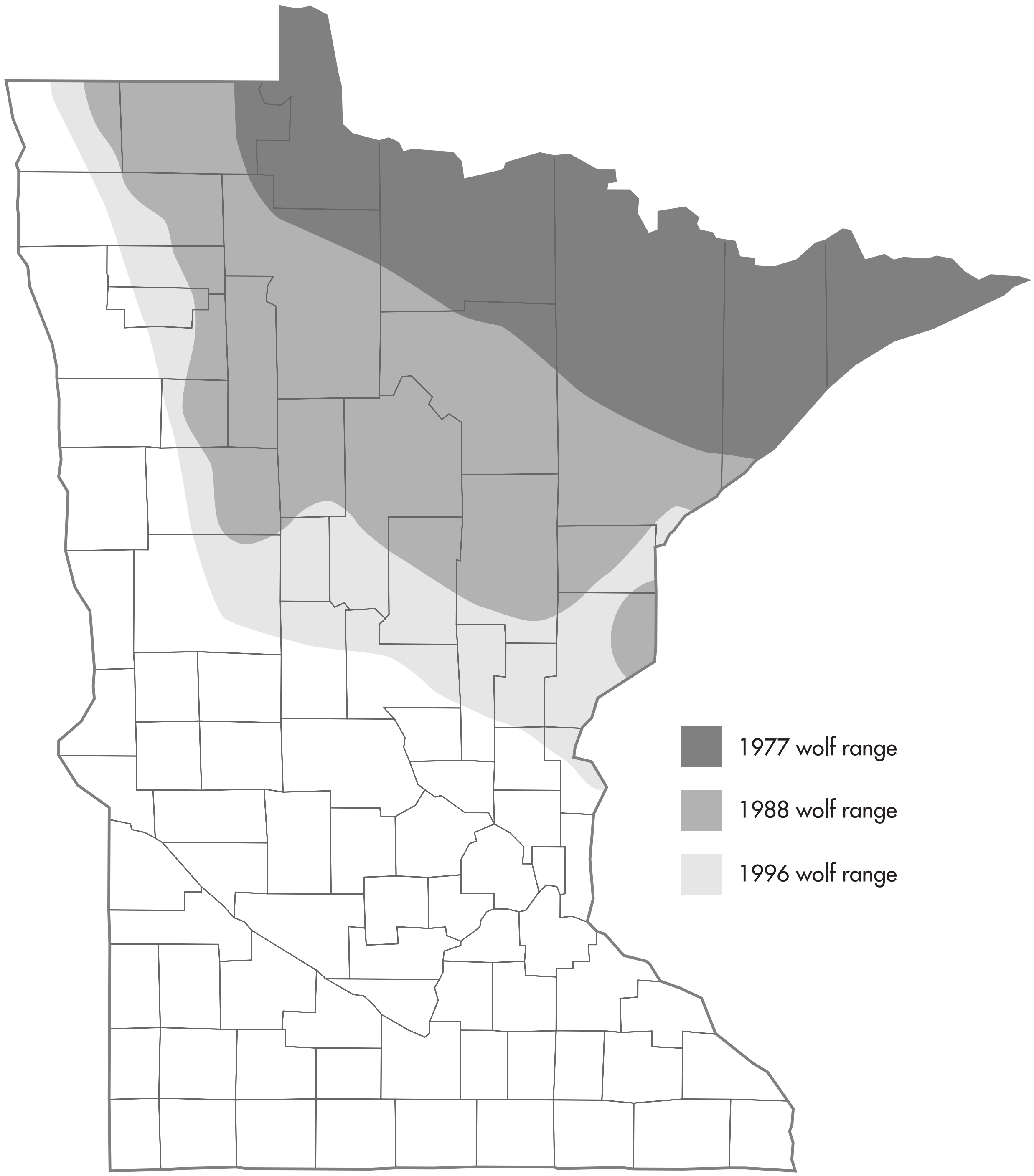
Minnesota Maps

Current Wolf Range in Minnesota



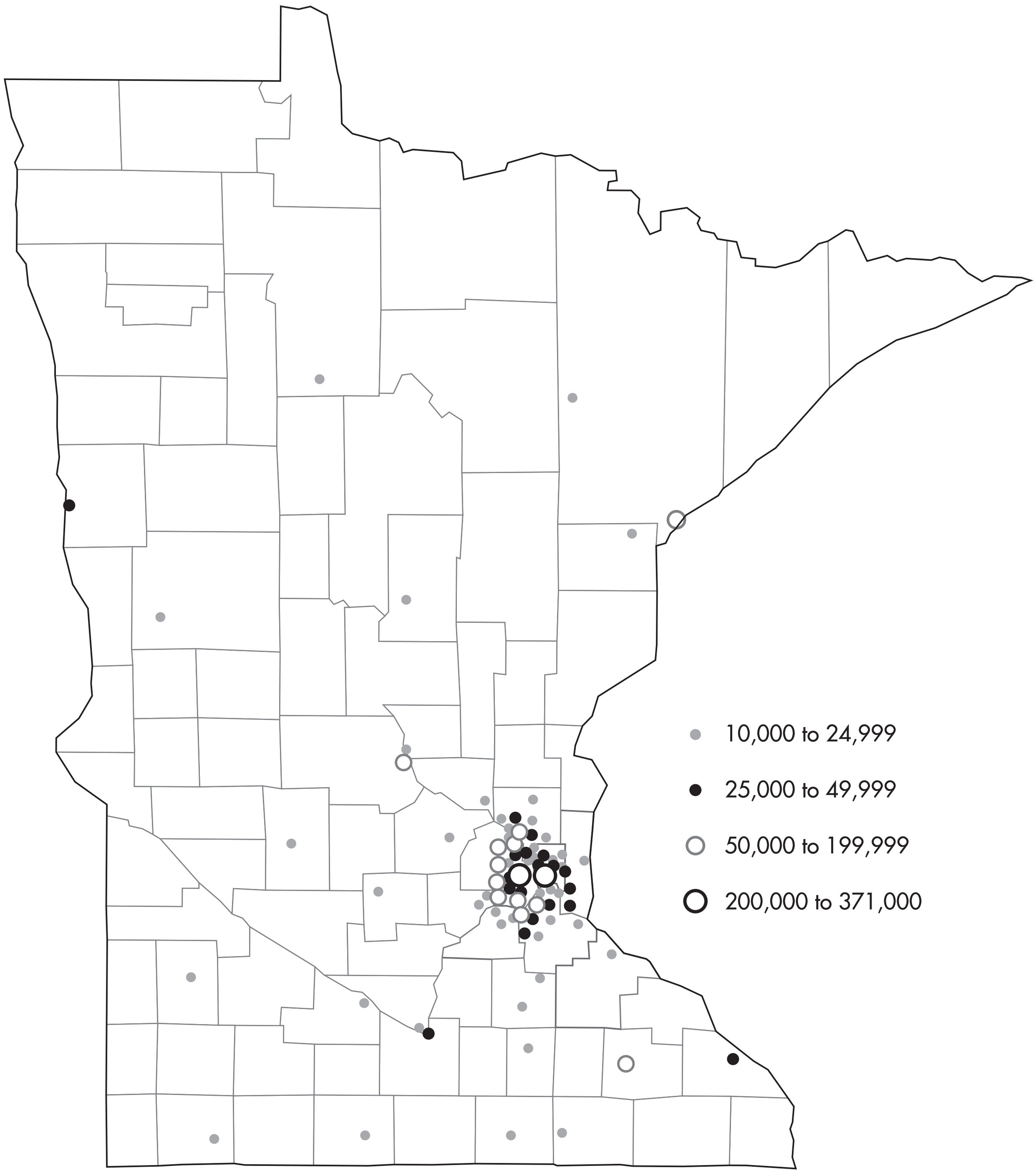
Source: International Wolf Center

Expansion Range by Contiguous Packs 1978–2005



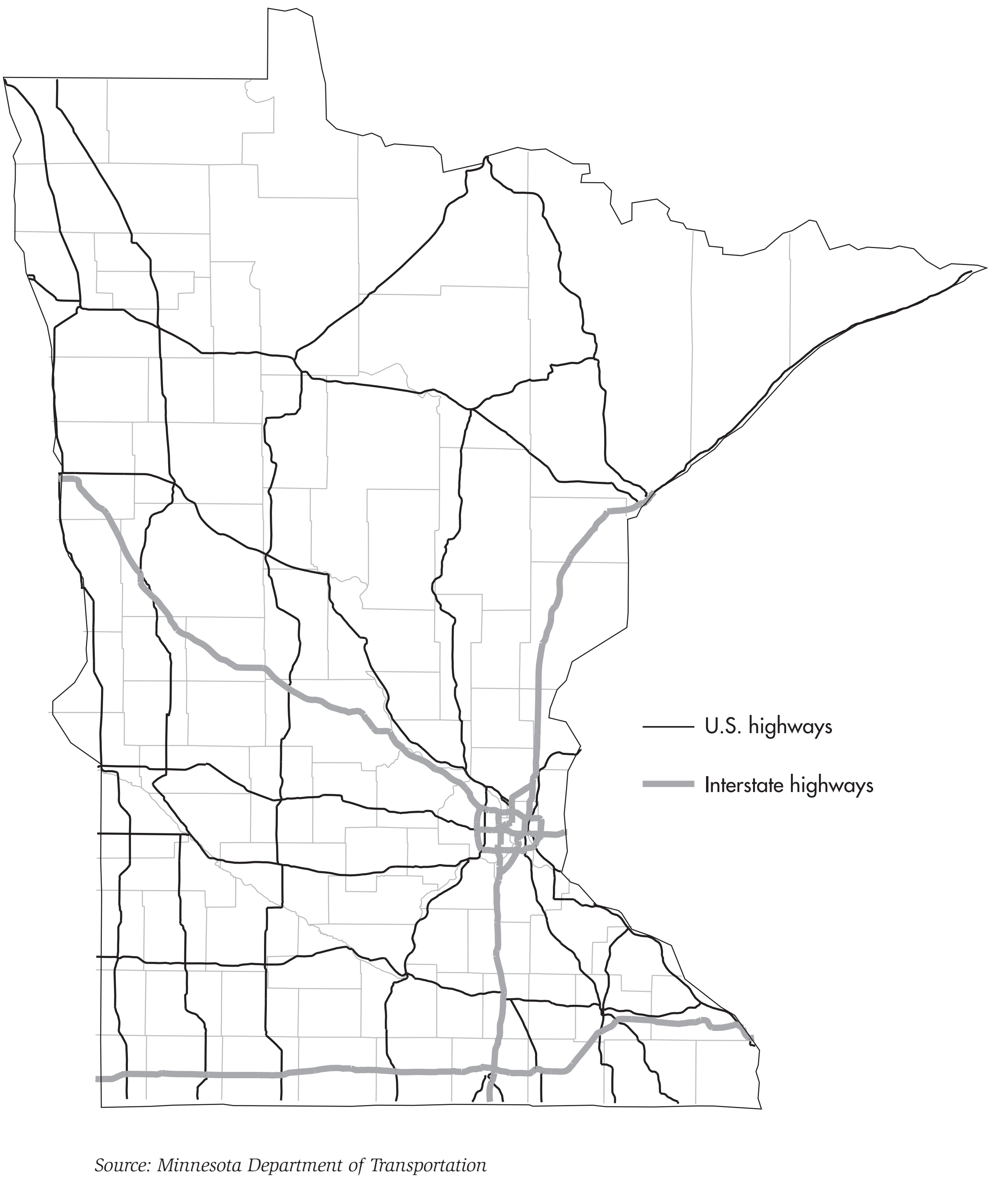
Source: International Wolf Center

Major Cities in Minnesota



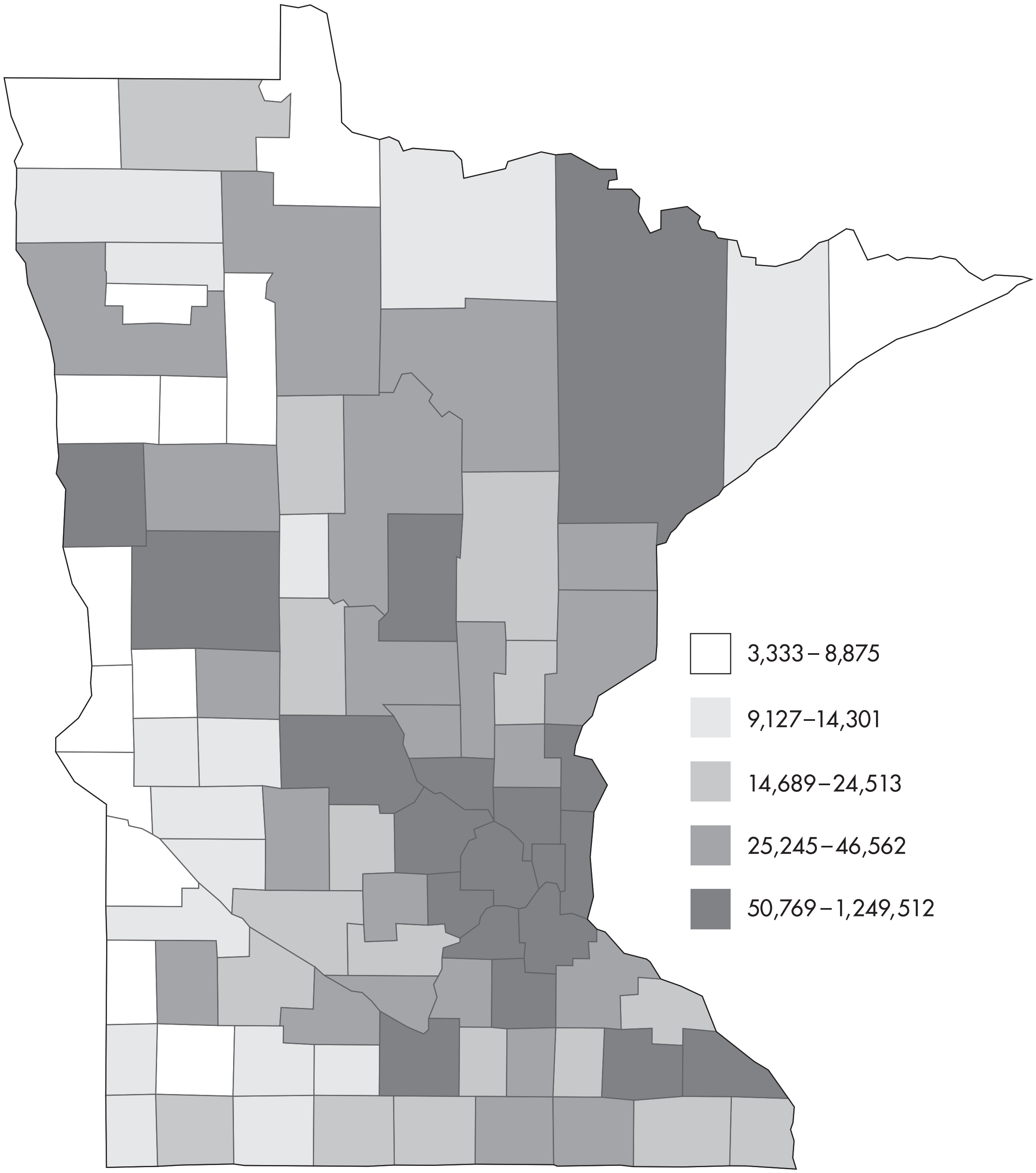
Source: Minnesota Department of Transportation

Major Highways in Minnesota



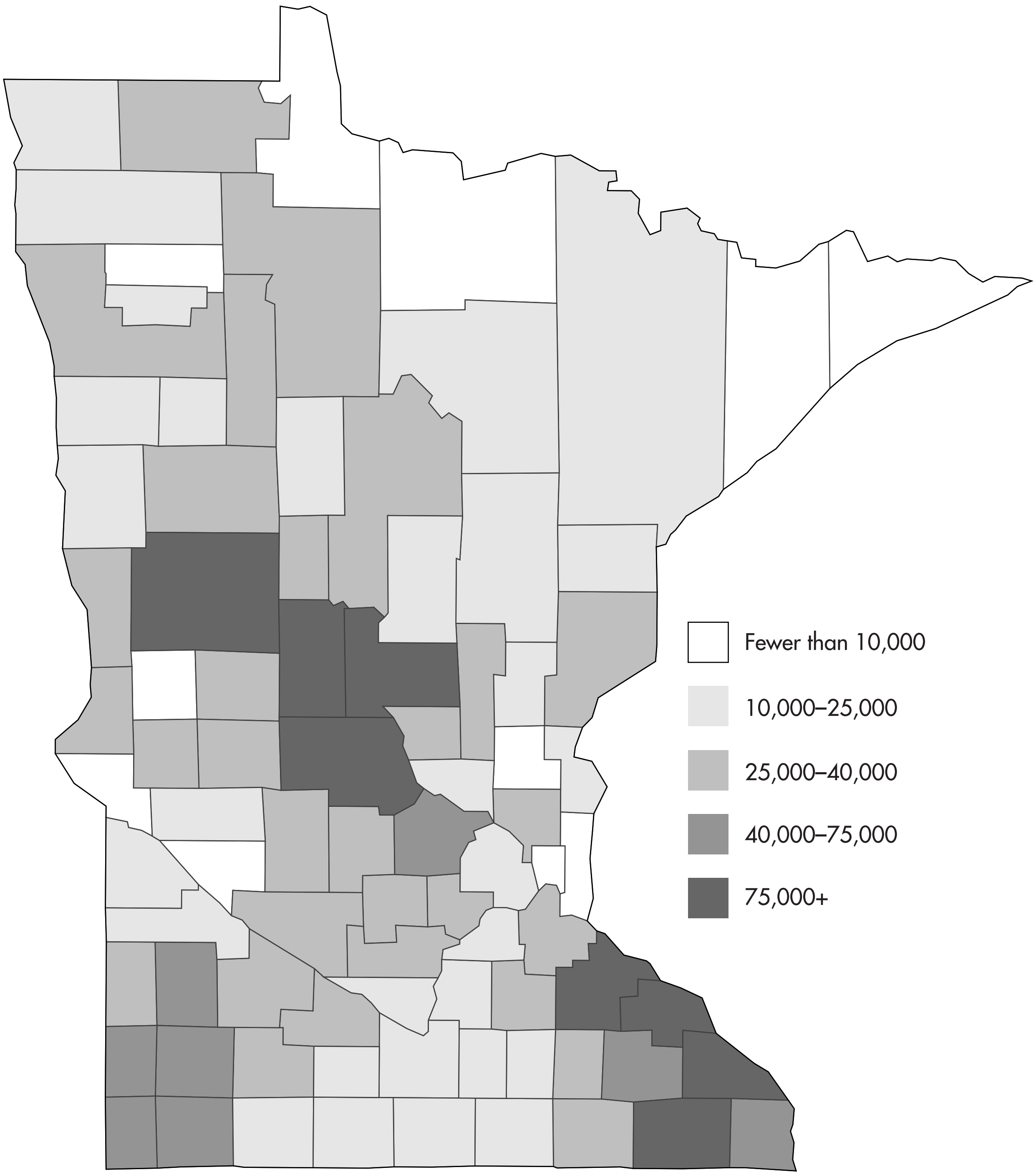
Source: Minnesota Department of Transportation

Minnesota Population by County



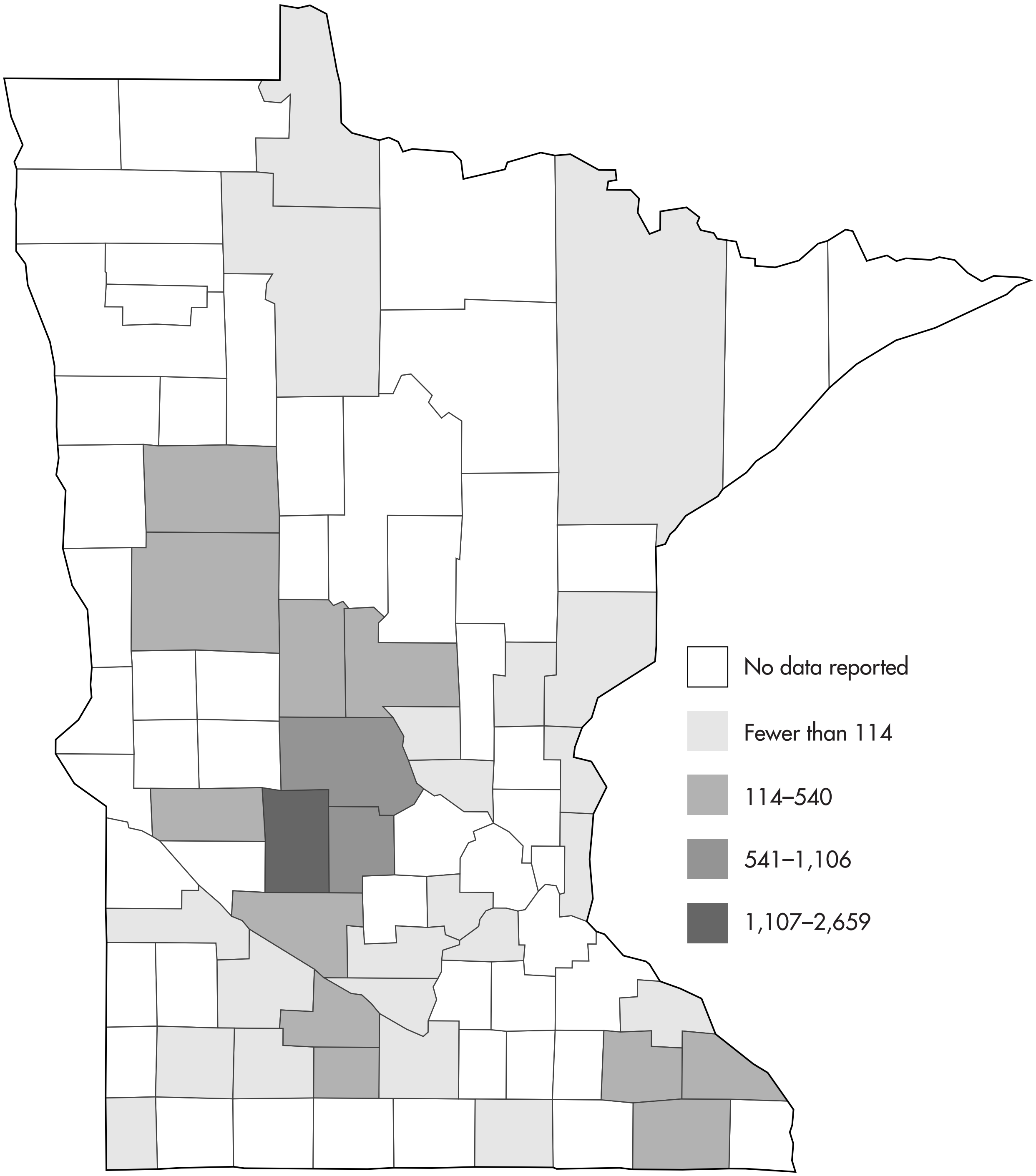
Source: Minnesota State Demographics Center

Head of Livestock (cattle, sheep)



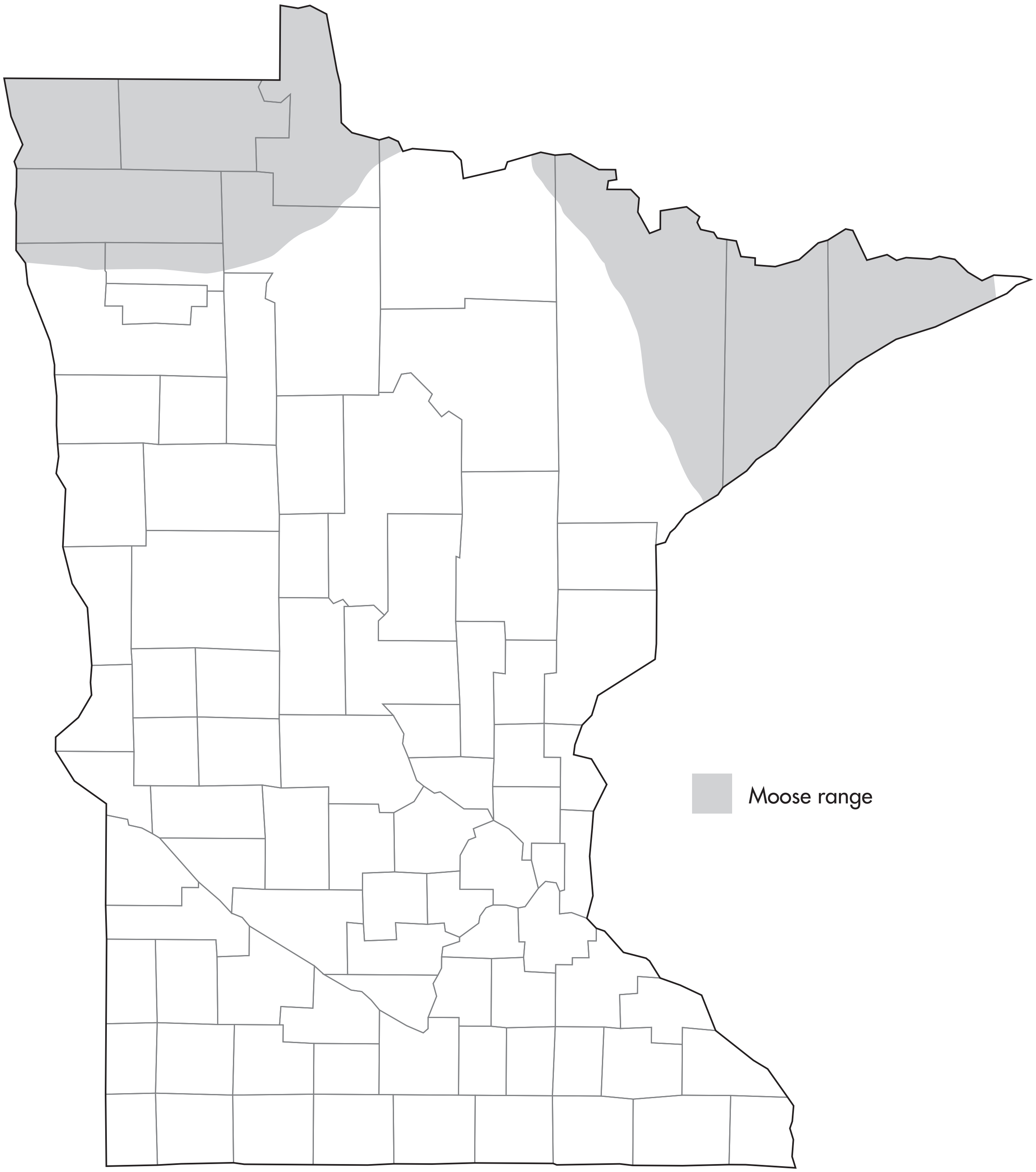
Source: Minnesota Agricultural Statistics Service

Turkeys in Minnesota



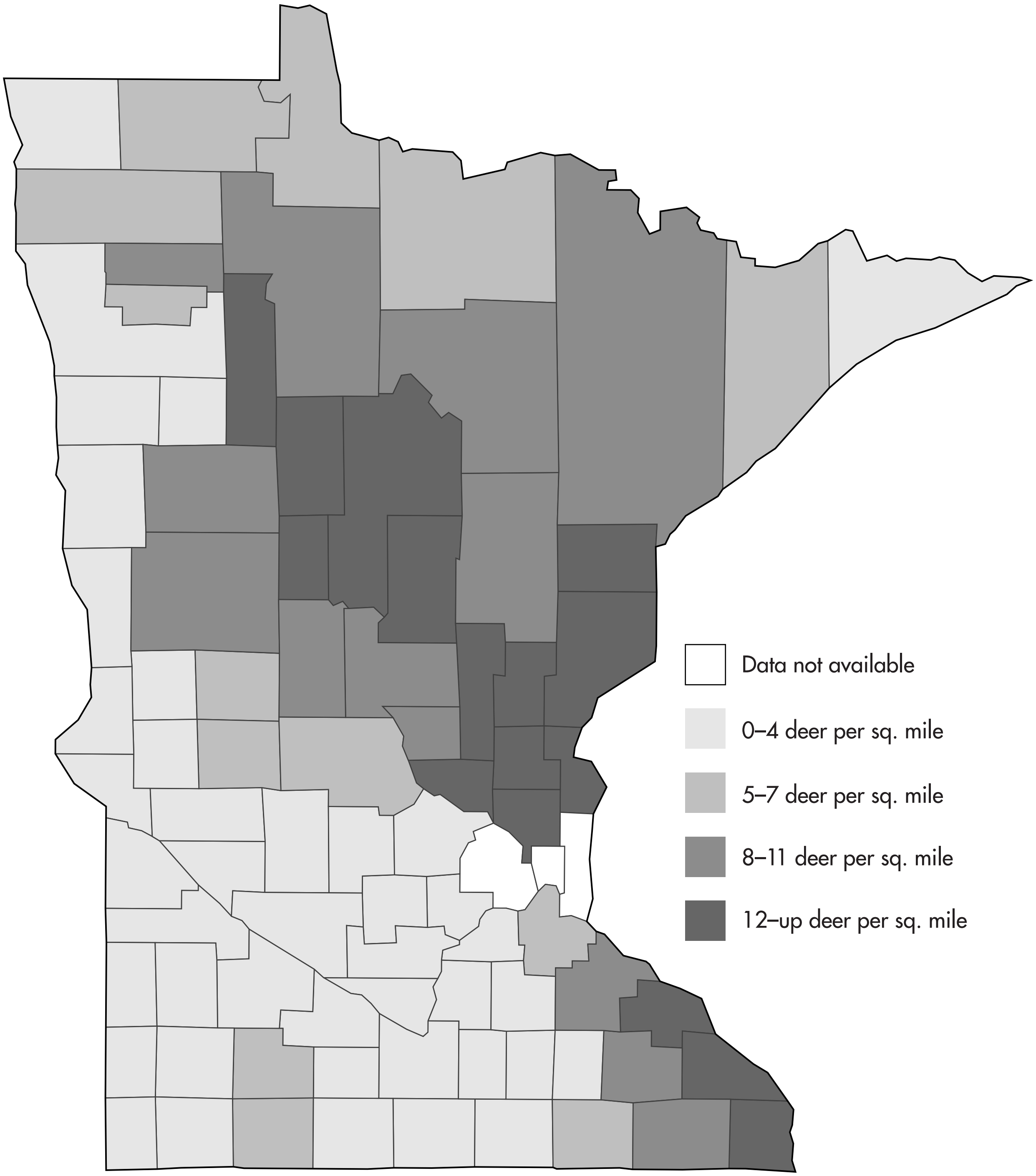
Source: Minnesota Agricultural Statistics Service

Moose Range in Minnesota



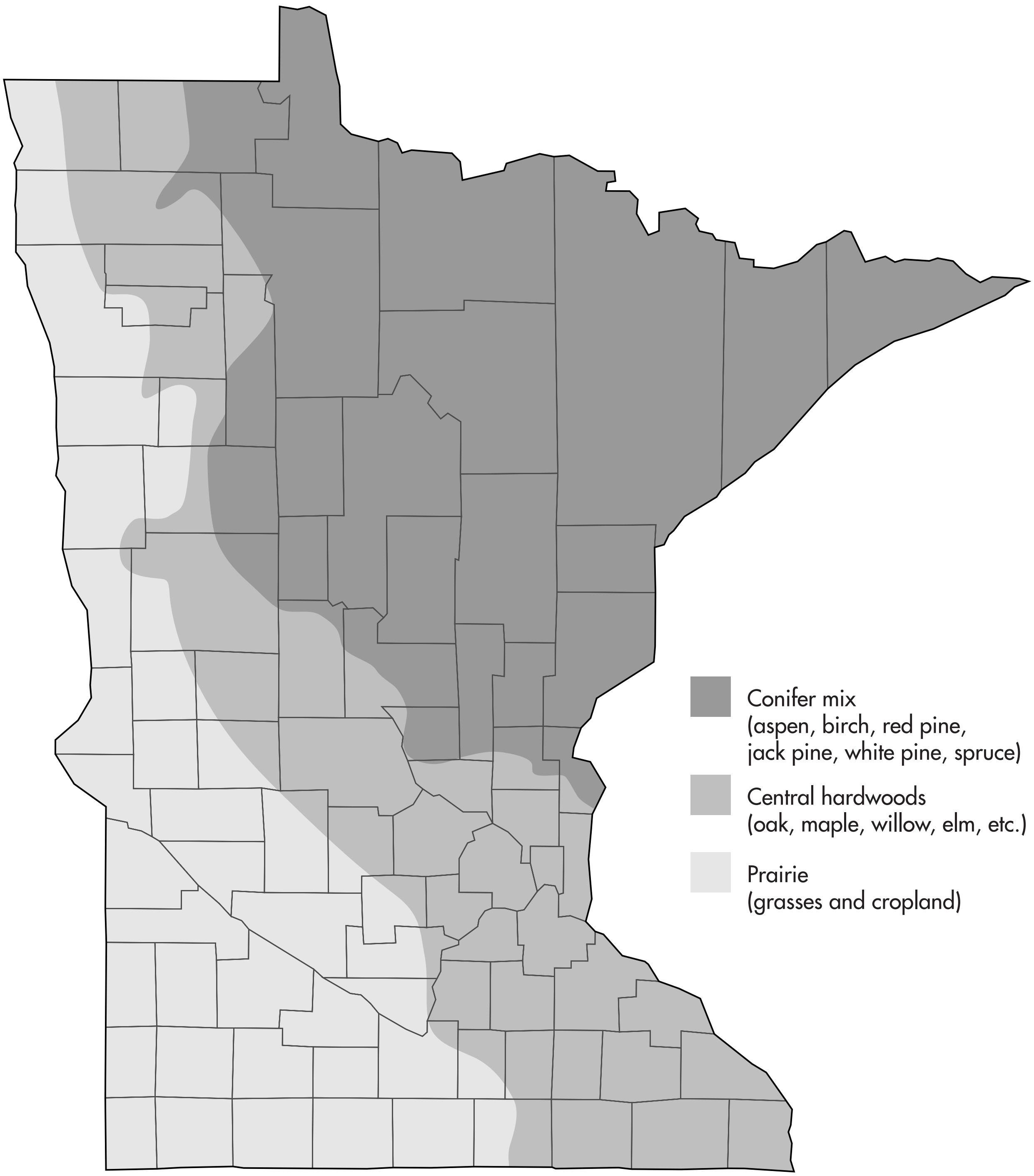
Source: Minnesota Department of Natural Resources

Deer in Minnesota



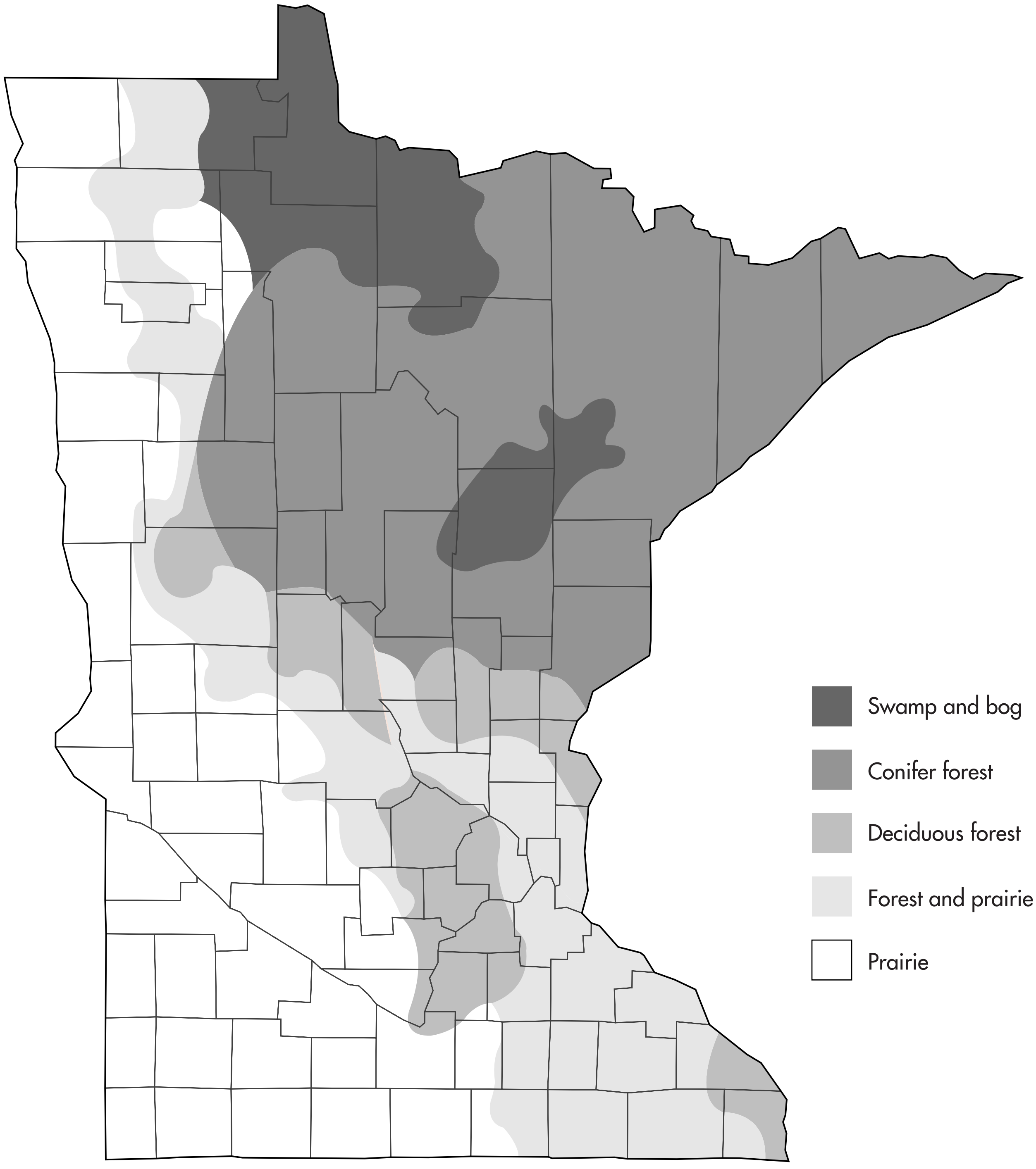
Source: Minnesota Department of Natural Resources

Major Vegetation Types in Minnesota,
today



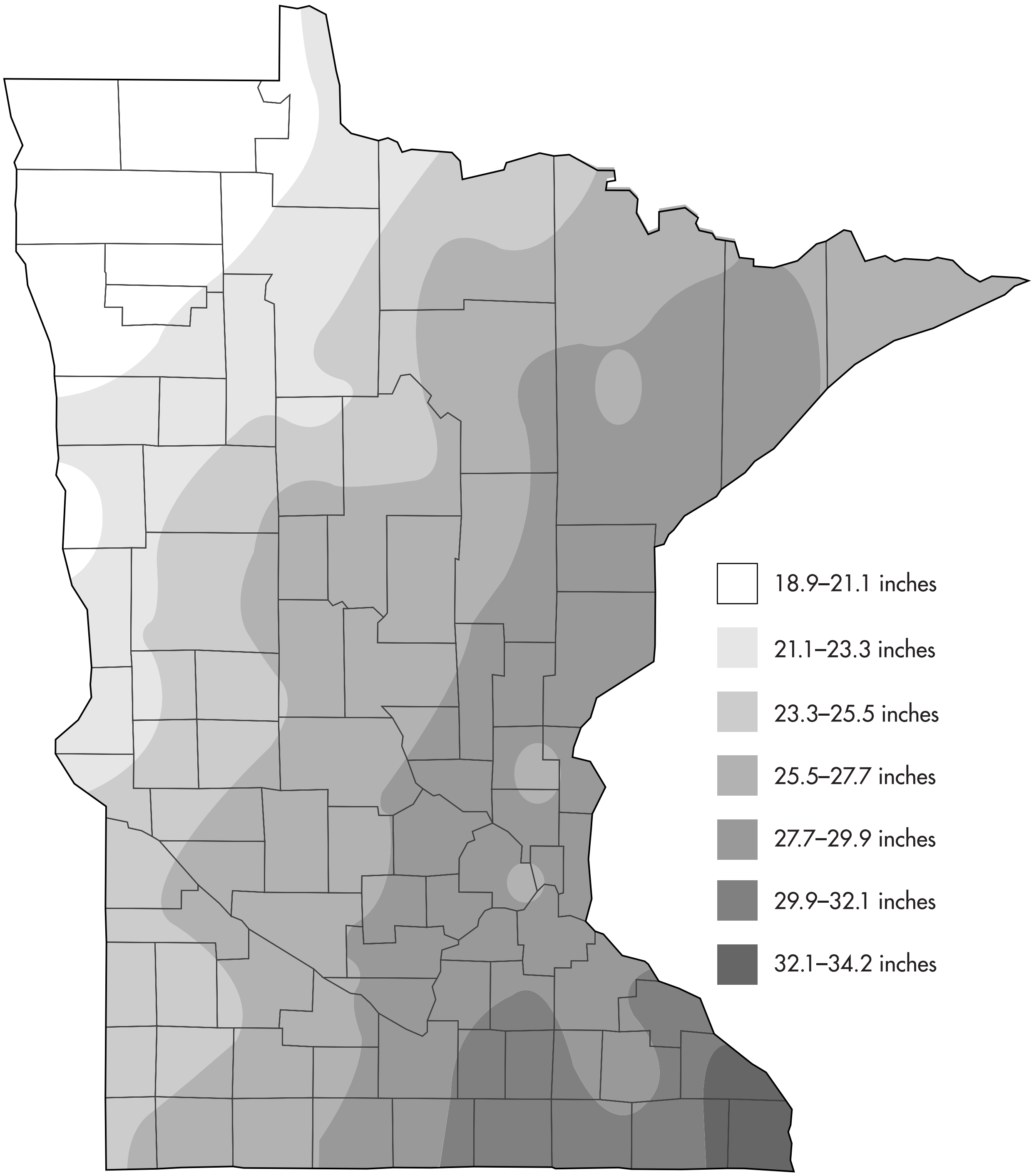
Source: Minnesota Department of Natural Resources

Minnesota Native Vegetation, late 1800s



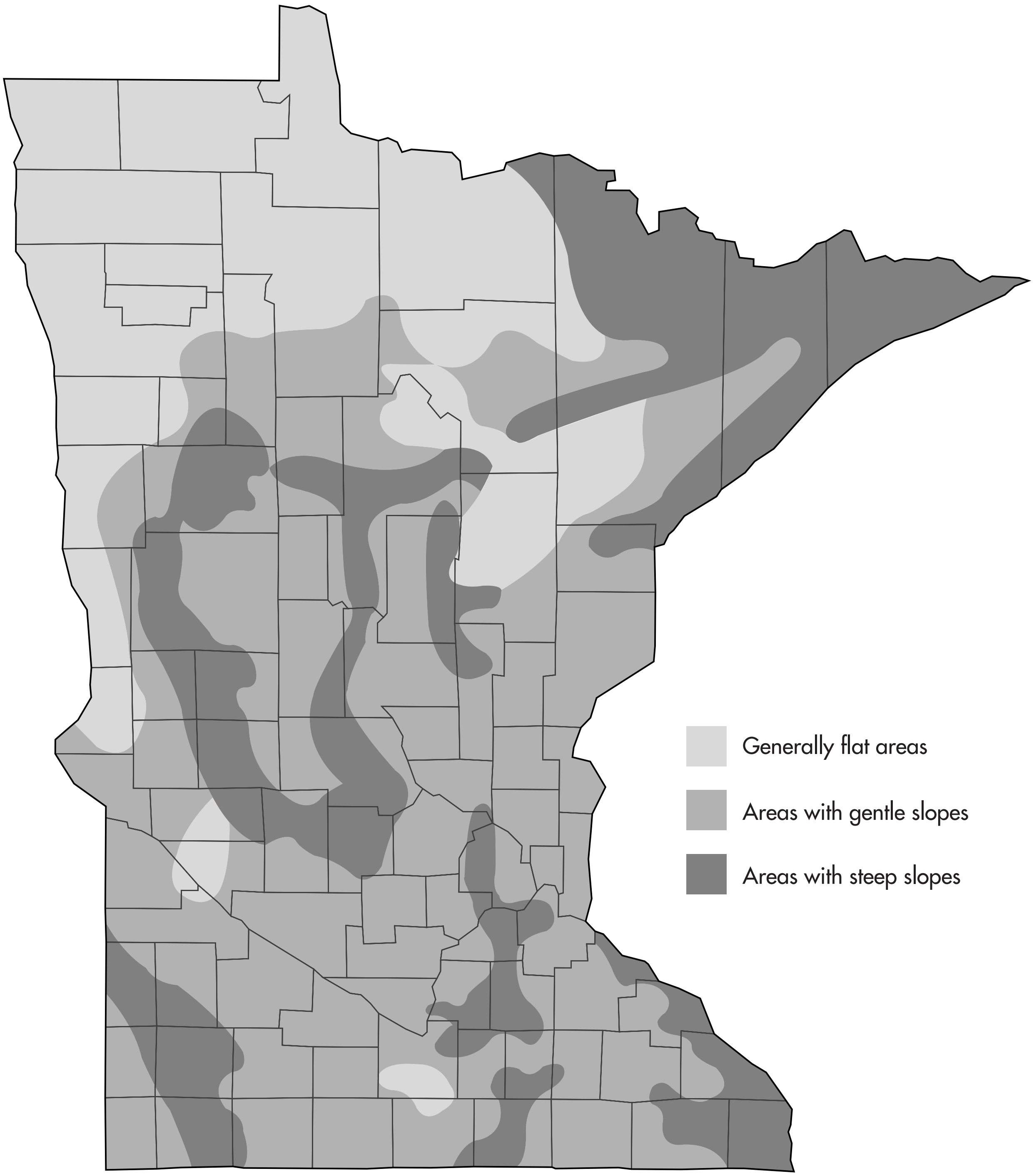
Source: Adapted from Minnesota Department of Natural Resources map that summarizes Public Land Survey 1847-1907

Minnesota Annual Precipitation



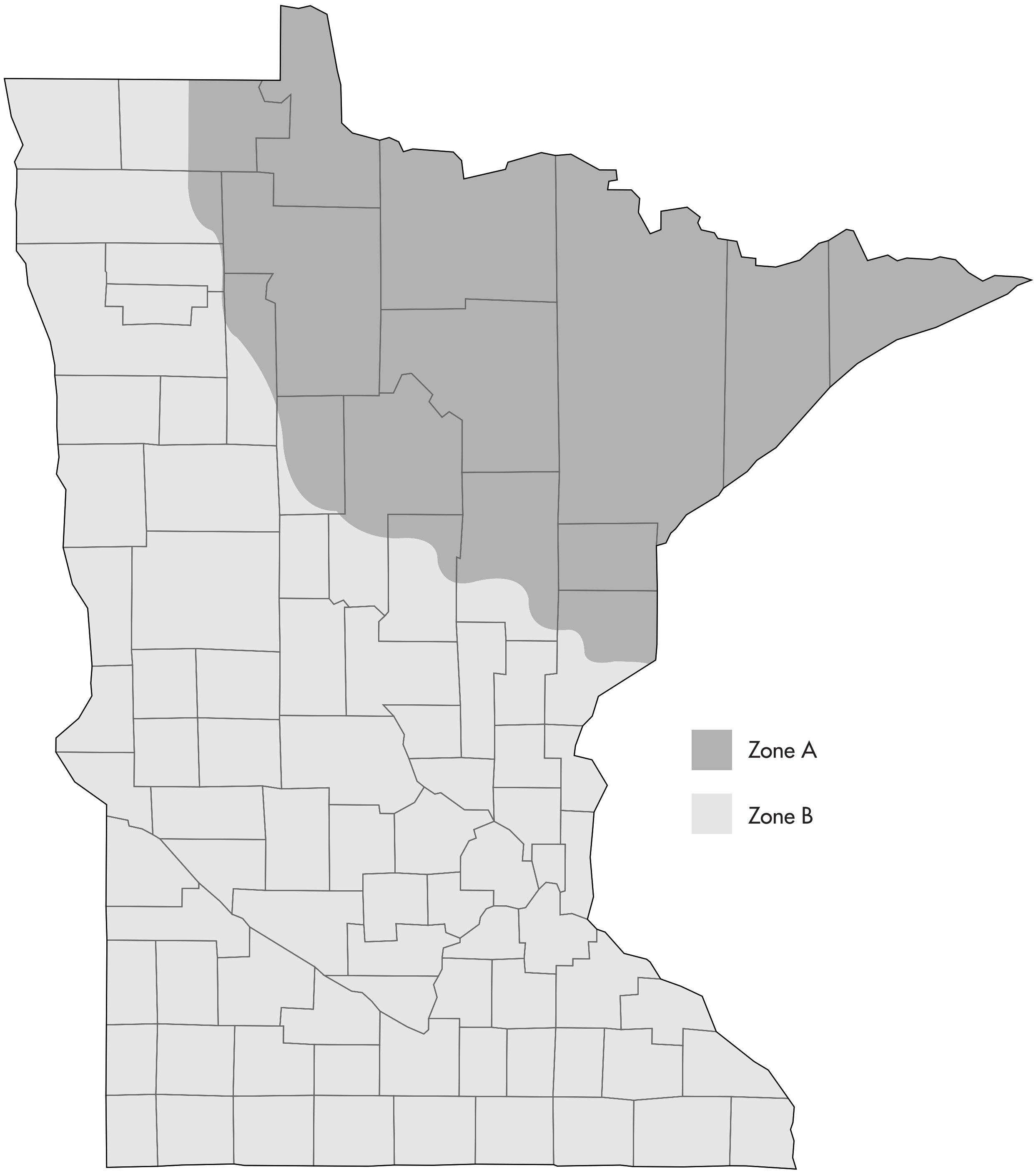
Annual average based on records for 1951-80
Source: Minnesota Weather *by Keen; weather station records*

Landforms in Minnesota



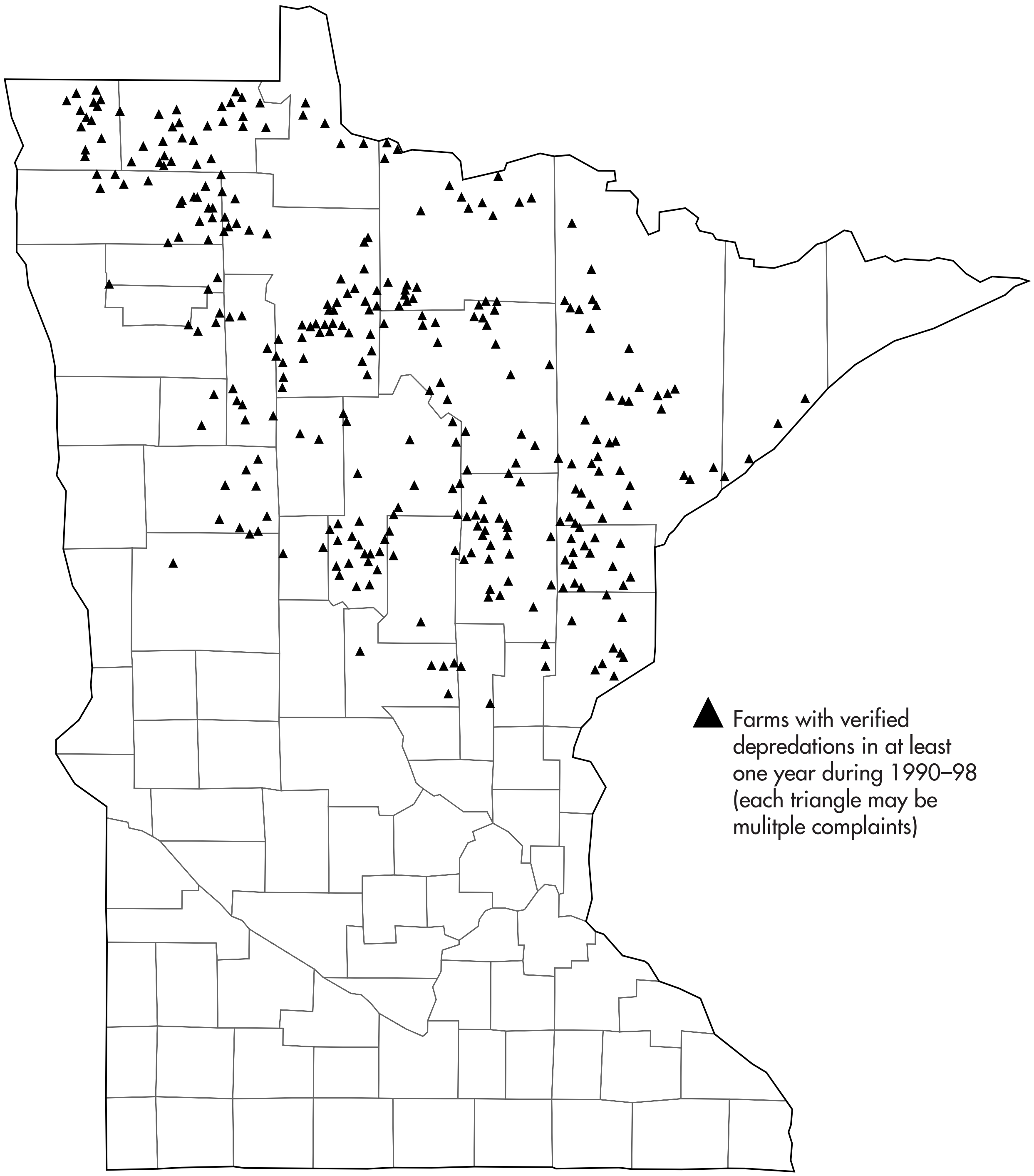
Source: Adapted from Landforms map in Atlas of Minnesota Resources and Settlement *by Borchert and Gustafson*

Minnesota DNR Management Zones



Source: Minnesota Department of Natural Resources

Wolf Depredation



Source: Liz Harper

Minnesota