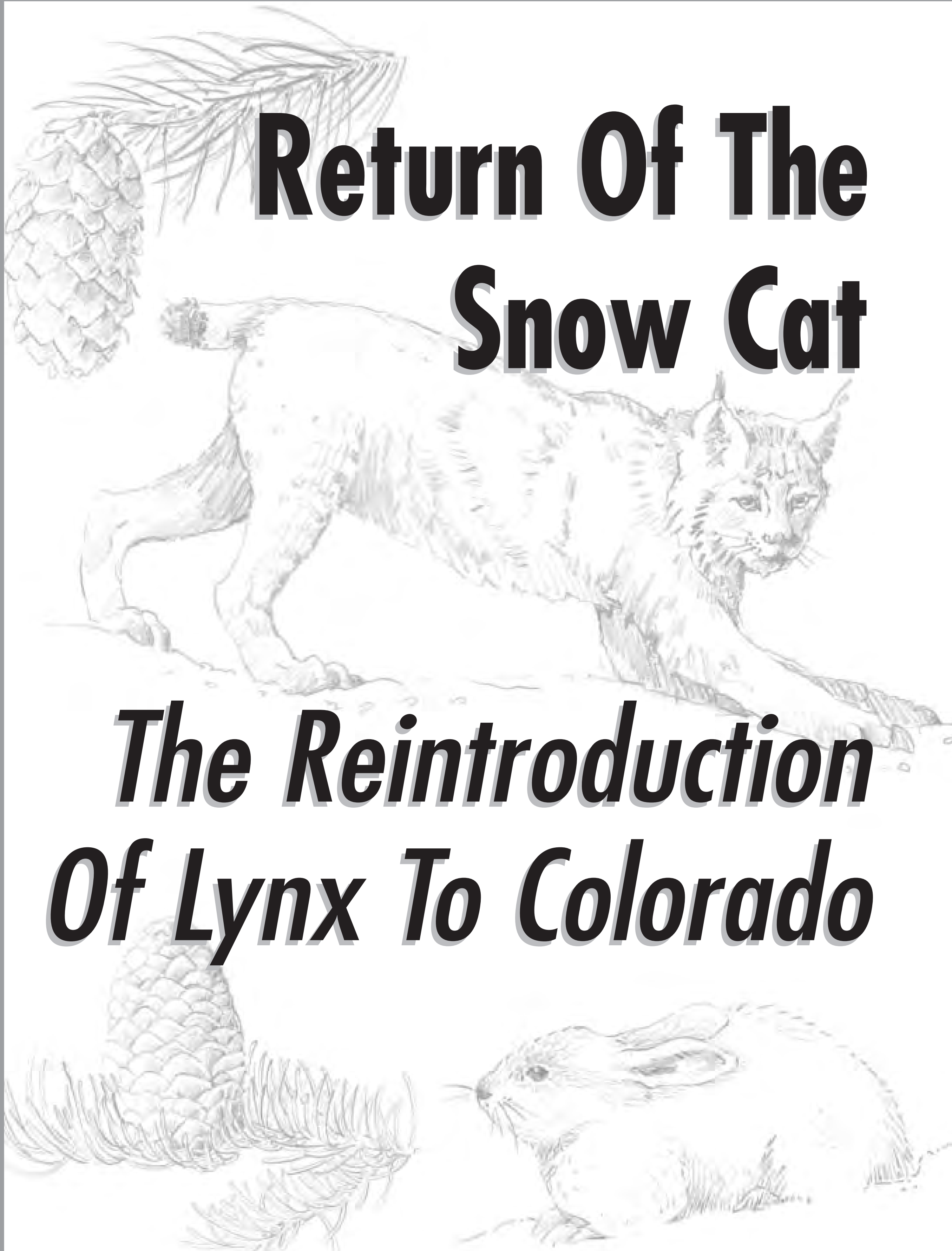
Return Of The Snow Cat

The Reintroduction Of Lynx To Colorado



STATE OF COLORADO

Bill Owens, Governor
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WILDLIFE
AN EQUAL OPPORTUNITY EMPLOYER

Bruce McCloskey, Director
6060 Broadway
Denver, Colorado 80216
Telephone: (303) 297-1192

*For Wildlife-
For People*

October 17, 2005

Dear Educator,

Colorado's rich wildlife heritage is a source of pride for our citizens. For more than 100 years, the Colorado Division of Wildlife (DOW) has been dedicated to protecting this legacy, so that future generations will continue to share this grand landscape with a diversity of wild creatures. Reintroductions of wildlife and studies aimed at gathering information about species and habitat have become critical conservation practices in the 21st century. Some of the DOW's most tangible accomplishments are reintroductions and we intend to continue this tradition by reestablishing a viable population of Canada lynx to its native range in Colorado.

Reintroducing or recovering a species is a big effort. State and federal agencies, non-profits and private citizens have united to make Colorado's lynx reintroduction a model for future species restoration. What we have learned and will continue to learn can now be a powerful and incredibly motivating teaching tool in your classroom. Many of North America's top researchers have gathered the information found in these lessons. With that expertise in hand, we invite you and your students to join us as we attempt to accomplish a feat of which all Coloradans can be proud – the return of the snow cat to Colorado.

Sincerely,

Bruce L. McCloskey
Director

DEPARTMENT OF NATURAL RESOURCES, Russell George, Executive Director
WILDLIFE COMMISSION, Jeffrey Crawford, Chair • Tom Burke, Vice Chair • Ken Torres, Secretary
Members, Robert Bray • Rick Enstrom • Philip James • Claire O'Neal • Richard Ray • Robert Shoemaker
Ex Officio Members, Russell George and Don Ament

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The Reintroduction Of Lynx To Colorado

Cool Cats, Cool Science

One hundred years ago, Colorado had fewer than 2,000 elk, 7,000 deer, and 1,000 pronghorn. Through the efforts of involved citizens and the Colorado Division of Wildlife (DOW), our state now has more than 300,000 elk, 500,000 deer, and 60,000 pronghorn. The DOW has also restored diminishing populations of river otters, ospreys, peregrine falcons, bald eagles and greenback cutthroat trout to healthy levels.

Now, a historic and heroic project is underway to return the beautiful Canada lynx to its historic range in Colorado. The mid-size wildcat was presumed extirpated from the state and listed as “state endangered” in 1973. After many years searching for any remaining lynx, the Colorado Division of Wildlife began a pro-active reintroduction effort. The first lynx were released on February 3, 1999. By 2000, the regal cat with the short tail, large fur-covered paws and tufted ears was listed as “threatened” under the federal Endangered Species Act. Colorado’s lynx restoration project seeks to prevent the lynx from ever reaching “endangered” status, and hopefully to delist them altogether.

This is only the second time in North America that a lynx reintroduction has been attempted. The first effort to establish lynx in Adirondack Park in New York in the late 1980’s failed. There was no adequate monitoring plan, and it was impossible to discern where the project went wrong. When Colorado decided to undertake this project, the state put in place stringent scientific monitoring. Not only would this experimental approach enhance the success of the reintroduction, it would allow scientists to add to a growing body of knowledge about species restoration.

The reintroduction sounds interesting, but you may wonder what’s in it for you and your students. Are you interested in providing students with an opportunity to explore the applications of science to real issues? Do you long for materials with real depth that can allow your students to explore a topic in many ways? Do you want your students to use real (and current) research data to analyze, draw conclusions about, and apply to real situations? Understand and interpret patterns from numbers? Use the scientific process to raise their own questions, develop hypotheses and examine data to test them? Develop critical reading skills? Understand the cross-disciplinary nature of science issues and problems? If you answered yes to any of these questions, this module is for you.

What is This?

This eight-lesson module, designed for two weeks of classroom instruction, teaches basic high school level ecology (ecosystems, population dynamics, and more) using real research data from the Colorado Division of Wildlife’s lynx reintroduction efforts. The module is designed to supplement or replace the activities found in most high school biology, ecology, or environmental science textbooks that address these topics. It is the first module developed by the DOW to address the specific learning objectives of high school students. Materials are inquiry-based, develop critical thinking skills, supply evidence to support each concept, and include a field research experience.

Using *Return Of The Snow Cat: The Reintroduction Of Lynx To Colorado* in Your Classroom

The lessons in this module are designed to be taught in sequence. For each activity, the students take on the role of a scientist, receive an introduction to the problem and to their task, are required to choose relevant information, and collect, record, and analyze data.

To supplement this module, each regional DOW office has a Lynx Loan Box available for check out. The box contains pelts and skulls of many subalpine animals, additional lessons, print material, and videos. Contact the Education Coordinator in your region to reserve the loan box:

Stan Johnson, Education Coordinator,
NW Region
711 Independent Ave.
Grand Junction, CO 81505
970-255-6191

Linda Groat, Rural Education Specialist,
SE Region
2500 S. Main
Lamar, CO 81052
719-336-6608

Steve Lucero, Education Coordinator
SE Region
4255 Sinton Road
Colorado Springs, CO 80907
719-227-5203

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317 W. Prospect
Ft Collins, CO 80526
970-472-4343

Debbie Lerch-Cushman, Education Coordinator, Denver Metro Area
6060 Broadway
Denver, CO 80216
303-291-7328

Correlation to the Colorado Model Content Standards

Return Of The Snow Cat: The Reintroduction Of Lynx To Colorado supports teachers in their efforts to provide the knowledge and skills specified in the Colorado Model Content Standards and the corresponding grade level assessment frameworks.

Lynx

COLORADO MODEL CONTENT STANDARDS

Science	Lesson 1: Lynx Links	Lesson 2: Planning The "Purrrfect" Comeback	Lesson 3: Map That Cat	Lesson 4: Built-in Snowshoes	Lesson 5: Hare Today, Gone Tomorrow	Lesson 6: No Cat Is An Island	Lesson 7: It's A Plot!	Lesson 8: Seven Steps To Success
1: Students understand the processes of scientific investigation and design. They conduct, communicate about and evaluate such investigations.	X	X		X	X	X	X	X
2.3: Students understand that interactions can produce changes in a system, although the total quantities of matter and energy remain unchanged.				X				
3.1: Students know and understand the characteristics of living things, the diversity of life, and how living things interact with each other and with their environment.	X	X	X	X	X	X	X	X
3.3: Students know and understand how the human body functions, factors that influence its structures and functions, and how these structures and functions compare with those of other organisms.				X				
5: Students know and understand inter-relations among science, technology, and human activity and how they can affect the world.	X					X	X	X
6: Students understand that science involves a particular way of knowing and understand common connections among scientific disciplines.	X	X			X	X	X	X

COLORADO MODEL CONTENT STANDARDS

Reading and Writing	Lesson 1: Lynx Links	Lesson 2: Planning The "Purrrfect" Comeback	Lesson 3: Map That Cat	Lesson 4: Built-in Snowshoes	Lesson 5: Hare Today, Gone Tomorrow	Lesson 6: No Cat Is An Island	Lesson 7: It's A Plot!	Lesson 8: Seven Steps To Success
1: Students read and understand a variety of materials.	X	X	X	X	X	X	X	X
2: Students write and speak for a variety of purposes and audiences.					X			X
3: Students write and speak using conventional grammar, usage, sentence structure, punctuation, capitalization, and spelling.					X			X
4: Students apply thinking skills to their reading, writing, speaking, listening, and viewing.	X	X	X	X	X	X	X	X
5: Students read to locate, select, and make use of relevant information from a variety of media, reference, and technological sources.	X	X			X		X	X

COLORADO MODEL CONTENT STANDARDS

Mathematics	Lesson 1: Lynx Links	Lesson 2: Planning The "Purrrfect" Comeback	Lesson 3: Map That Cat	Lesson 4: Built-in Snowshoes	Lesson 5: Hare Today, Gone Tomorrow	Lesson 6: No Cat Is An Island	Lesson 7: It's A Plot!	Lesson 8: Seven Steps To Success
1: Students develop number sense and use numbers and number relationships in problem-solving situations and communicate the reasoning used in solving these problems.			X	X	X	X	X	
2: Students use algebraic methods to explore, model, and describe patterns and functions involving numbers, shapes, data, and graphs in problem-solving situations and communicate the reasoning used in solving these problems.					X			
3: Students use data collections and analysis, statistics, and probability in problem-solving situations and communicate the reasoning used in solving these problems.		X		X	X	X	X	X
4: Students use geometric concepts, properties, and relationships in problem-solving situations and communicate the reasoning used in solving these problems.				X				
5: Students use a variety of tools and techniques to measure, apply the results in problem-solving situations, and communicate the reasoning used in solving these problems.			X	X	X		X	
6: Students link concepts and procedures as they develop and use computational techniques, including estimation, mental arithmetic, paper-and-pencil, calculators, and computers, in problem-solving situations and communicate the reasoning used in solving these problems.		X	X	X	X	X	X	X

COLORADO MODEL CONTENT STANDARDS

Geography	Lesson 1: Lynx Links	Lesson 2: Planning The "Purrrfect" Comeback	Lesson 3: Map That Cat	Lesson 4: Built-in Snowshoes	Lesson 5: Hare Today, Gone Tomorrow	Lesson 6: No Cat Is An Island	Lesson 7: It's A Plot!	Lesson 8: Seven Steps To Success
1: Students know how to use and construct maps, globes, and other geographic tools to locate and derive information about people, places, and environments.			X		X	X	X	
2: Students know the physical and human characteristics of places, and use this knowledge to define and study regions and their patterns of change.	X	X						
3: Students understand how physical processes shape Earth's surface patterns and systems.	X	X	X	X	X	X	X	
5: Students understand the effects of interactions between human and physical systems and the changes in meaning, use and importance of resources.	X	X			X	X		

Notes

Lesson 1

Educator's Overview

Lynx Links

Duration

One 45-minute class period

Vocabulary

Bag limit

Candidate species

Census method

Colorado Division of Wildlife (DOW)

Conterminous 48 states

District Wildlife Manager (DWM)

Endangered

Endangered Species Act (ESA)

Extirpated

Extinct

Game animal

Habitat

Natural resource

Population

Recovered

Recovery plan

Reintroduction

Season

Species of special concern

Threatened

U.S. Fish and Wildlife Service (USFWS)

Viable population

Wildlife management

Summary

This activity is designed to build active science reading skills, and establish basic vocabulary and concepts for understanding what wildlife management is, who does it, what lynx are, and some history of lynx in Colorado. This activity serves as a foundation to study lynx ecology and the science of reintroducing species.

Learning Objectives

After completing this activity, students will be able to:

- Compare the features of Colorado's native felines: lynx, bobcat, and mountain lion.
- Construct a timeline illustrating the history of lynx in Colorado.
- Define wildlife management and list some wildlife management techniques.
- Define basic wildlife management terms by inferring meaning from the context in which the term is used.
- Distinguish between state and federal wildlife management agencies and the responsibilities of each.
- Define "threatened" and "endangered" as applied to wildlife and state and federal law.

Background

For many students and adults, reading science is like reading a foreign language. Whether the science writing is found in a textbook, a newspaper, a journal, or on the Internet, it often contains vocabulary that is unique to that science area. Even words and phrases that are familiar can be used in different ways and have different meanings in a scientific context. For example, a wildlife biologist using the terms "game," "community," or "seasons" is rarely referring to Bingo, her neighborhood, or summer.

For students to be able to make sense of what they read, vocabulary development and the ability to access prior knowledge are crucial. Often the writer of scientific material takes for granted that the readers share the same basic knowledge and jargon. This first activity is designed to acknowledge this peculiar fault of scientists and begin to encourage students to think about strategies they might use to understand new words or concepts.

There will be some words presented in the student reading that are not directly defined. You and your students will probably notice these, as they are in bold text, just like some other words that are immediately followed with a definition. Students will be asked to make sense of these words without using a dictionary and later discuss their thinking processes.

While students are working on reading skills, they will be learning some key concepts related to lynx and wildlife management. These concepts will form a conceptual framework for students as they proceed through the remainder of the unit.

Teaching Strategies

1. Thoroughly read the student activity for *Lynx Links*.

2. This activity introduces the entire unit, ***Return of the Snow Cat: the Reintroduction of Lynx to Colorado*** to the students. This first activity, *Lynx Links*, provides a great opportunity to get students excited about the topic. Begin by playing the DVD: *Return of the Snow Cat: the Reintroduction of Lynx to Colorado* for students. Tell them that they will be studying about lynx and the extraordinary effort to restore populations of this native cat. Let students know this is a current issue—and an experiment of immense importance.

3. ***Optional:*** It is optional, but highly recommended, that you obtain a Lynx Loan Box from your Regional Colorado Division of Wildlife office (see module overview). The box contains lynx, bobcat, and mountain lion pelts and skulls which can be used for student observation.

You can begin by placing the colored photographs of the lynx, bobcat and lion in a visible place. If you have the loan box, place the skull replicas and pelts in a visible place as well.

4. Inform students that their research of lynx will involve not only various experiments and simulated activities, but also reading scientific materials from various sources. This initial reading will provide them with the background information and vocabulary they need to study this amazing animal.

Materials and Preparation

- *Laminated color photographs of lynx, bobcat, and mountain lion*
- *Student Reading and Activity Pages for* Lynx Links*—one photocopy per student*
- *DVD player and monitor*
- *DVD:* Return of the Snow Cat: The Reintroduction of Lynx to Colorado
- ***Optional:*** *Obtain* Lynx Loan Box *from DOW Regional Office*

5. Give each student Reading and Activity Pages for *Lynx Links*. After students have read individually, they can complete the activities either alone or in small groups.

6. Review the activities as a group. The discussion will give you a good opportunity to point out to students that they use some of the same skills in reading as they do in "hands-on" science: they engage prior knowledge, they hypothesize (I think the word means… because…), they evaluate, look for patterns, make inferences, and so on.

Assessment

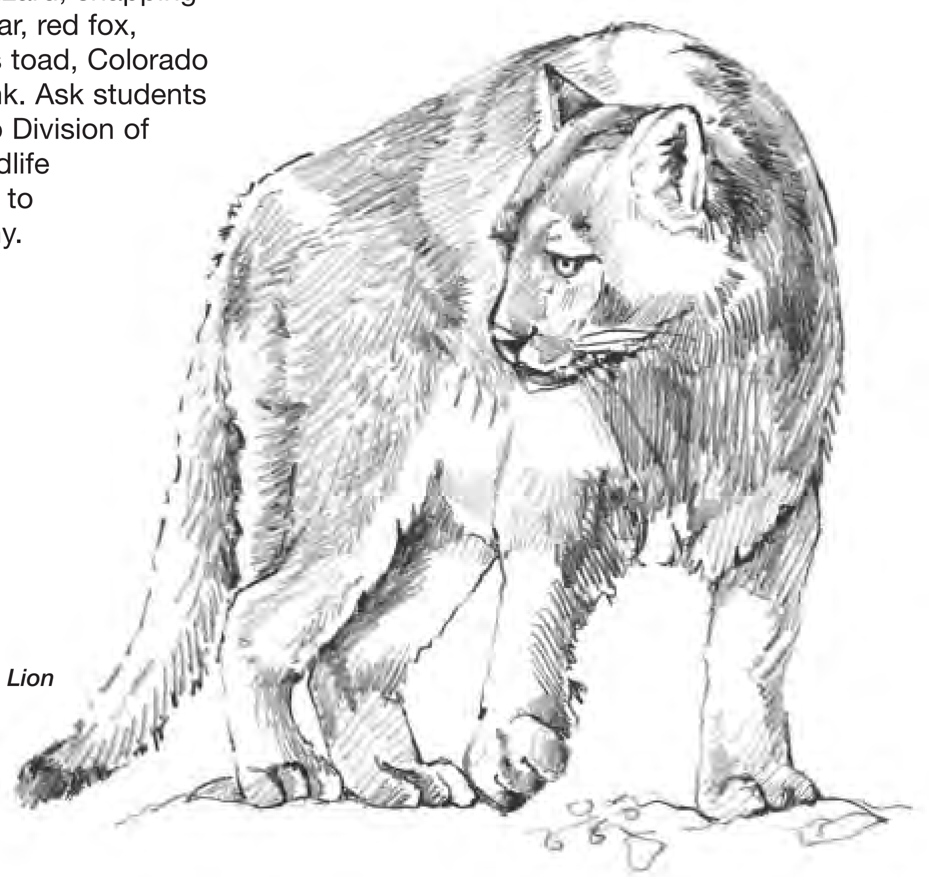
The student activities can serve as an assessment for vocabulary, lynx history in Colorado, and lynx characteristics.

Provide students with this list of Colorado species: mule deer, golden eagle, bullsnake, tiger salamander, sagebrush lizard, snapping turtle, rainbow trout, black bear, red fox, American robin, Woodhouse's toad, Colorado pikeminnow, and striped skunk. Ask students to state whether the Colorado Division of Wildlife or the U.S. Fish & Wildlife Service has ultimate authority to manage each species and why.

(While both state and federal wildlife agencies may jointly manage species, the U.S. Fish & Wildlife Service has ultimate authority for all federally listed species and migratory birds: golden eagle, American robin, Colorado pikeminnow; while the Colorado Division of Wildlife manages the rest)

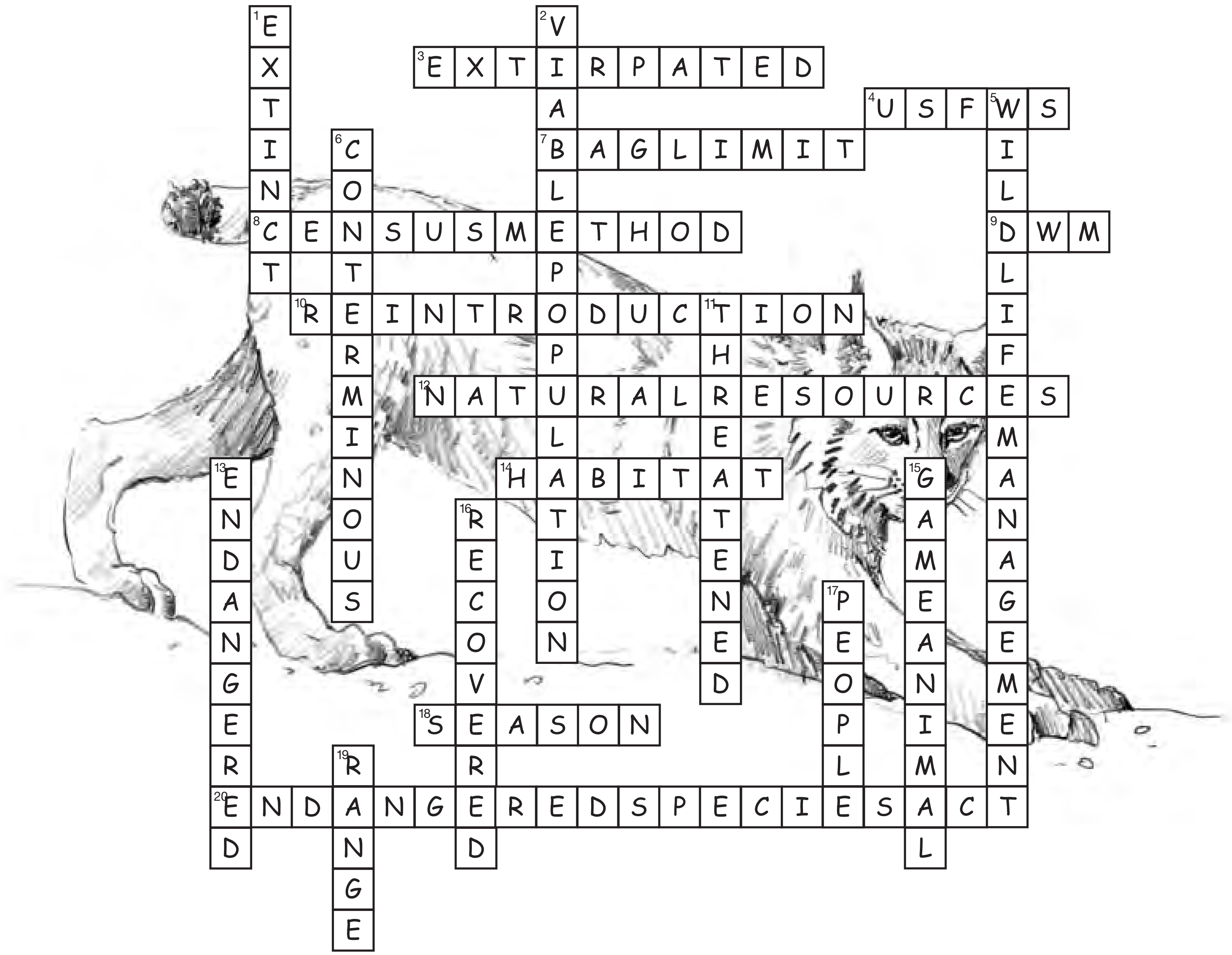
Extensions

- Research the names and responsibilities of the seven other divisions of Colorado's Department of Natural Resources.



Mountain Lion

Student Activity Answer Keys



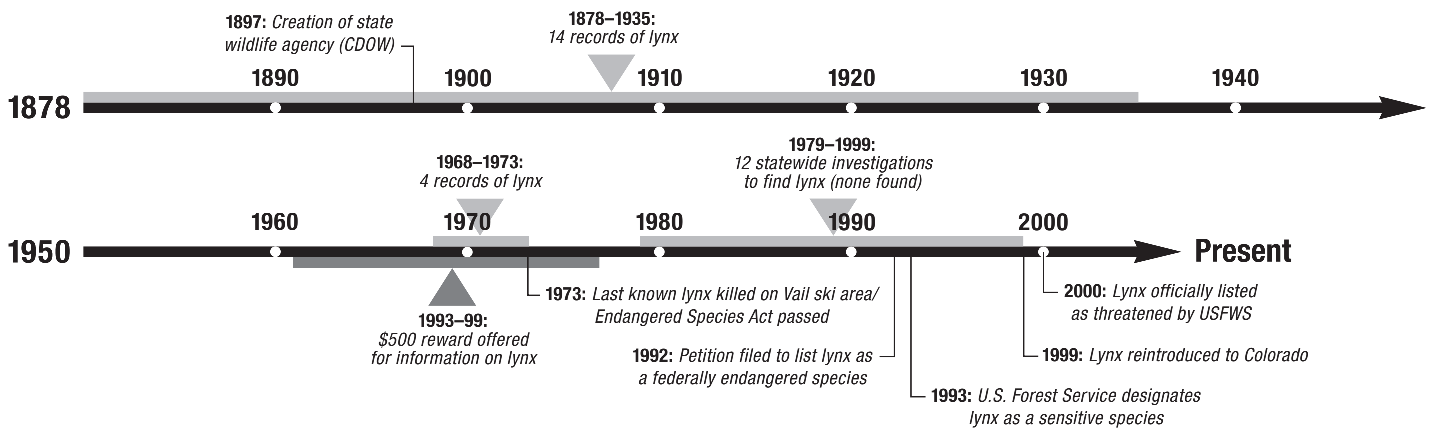
Across

3. A species that has been eliminated from part of its historical range
4. Agency responsible for managing migratory birds, marine mammals and federally “listed” species
7. The number of a species that can be harvested in a specified period of time
8. Method to count members of a population, part of population monitoring
9. A special Colorado biologist who is also a law enforcement officer
10. An attempt to re-establish a species in an area that was once part of its historical range
12. That portion of the environment that people have assigned value to or use
14. The arrangement of food, water, shelter and space suitable to an animal’s needs
18. The time of year one can hunt or fish
20. A 1973 federal law that protects animals and plants from extinction in this country

Down

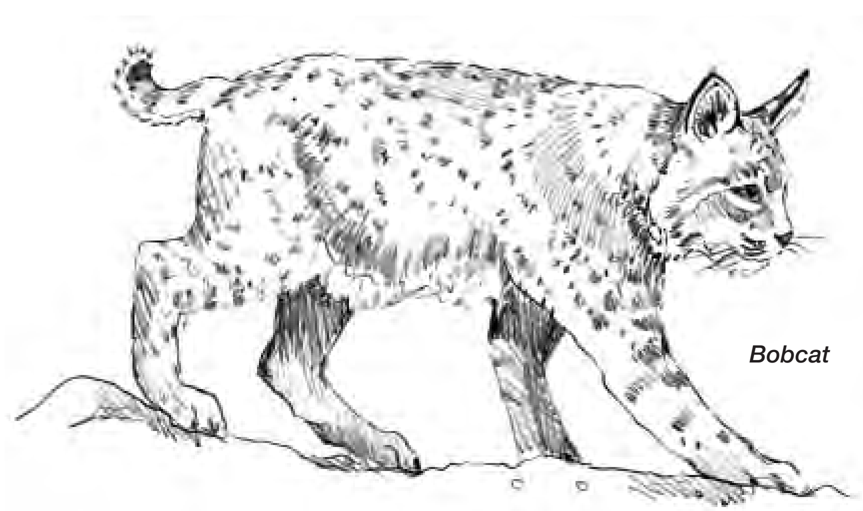
1. A species that no longer exists on this planet
2. Population that is large enough and healthy enough to be self-sustaining in the wild
5. The application of scientific knowledge to sustain wildlife and its habitat
6. Enclosed within one common boundary
11. Species that are vulnerable because they exist in small numbers or in a limited range
13. A species that is in immediate danger of becoming extinct in all or a large portion of its range
15. Animals that people can legally hunt, trap or fish
16. When a species population is large or healthy enough to be taken off the “list”
17. The owners of wildlife in the United States
19. The geographic region where a plant or animal species normally lives

This timeline represents one possibility; students' timelines should be similar.



Since students have been asked to choose the features to compare the three felines, this represents just one possible example of a comparison table.

	FEATURE					
	Weight	Tail	Tufts on Ears?	Spots or Stripes?	Fur Color	Size of Feet
LYNX	20–30 lbs.	Bobbed, black tip	Yes	No	Uniform in color, thick and long	Large in proportion to body
BOBCAT	20–30 lbs.	Bobbed, black spot on top of tip, white below	Yes	Yes	Striped on body, not as thick	In proportion with the rest of the body
MOUNTAIN LION	130 lbs.	Long, black tip	No	No	Uniform color, not thick	In proportion with the rest of the body



Bobcat

Notes

Lesson 1

Student Pages

Lynx Links

Summary

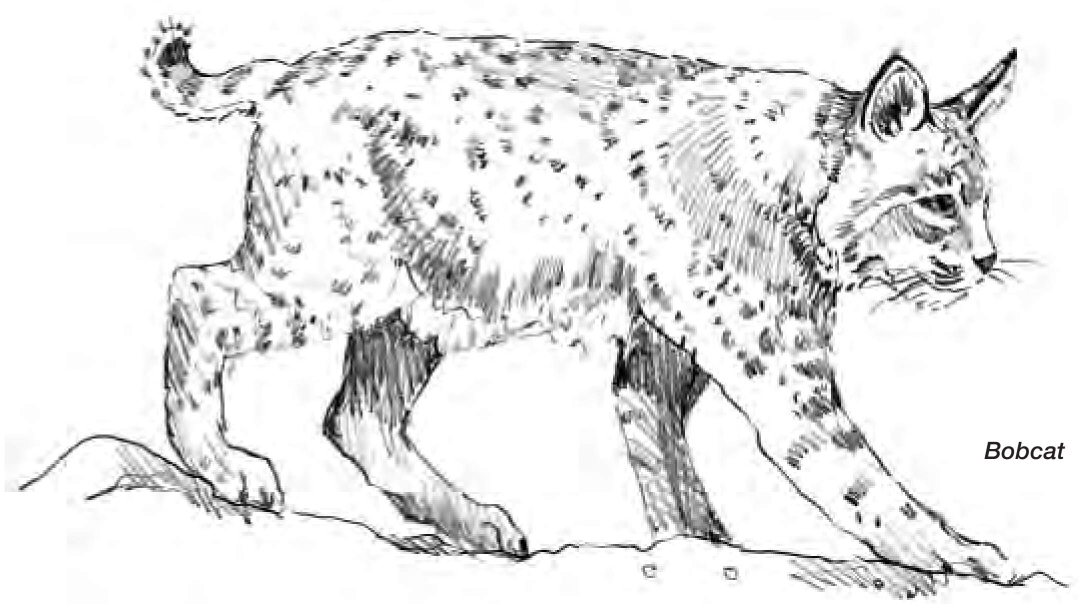
This first section provides you with a foundation for studying lynx reintroduction in Colorado—it will "link" together some basic concepts. Included is information about lynx and what is known about their history in our state, the science of wildlife management, and a working definition of reintroduction and its use as a management tool to recover wildlife species.

Lynx, the Snow Cat

The name lynx comes from the Greek word, *leukos*, which means white. That's not surprising, because these wild cats tend to live where there is a lot of snow. In fact, as you will soon discover, lynx are uniquely suited to travel and hunt in deep snow.

The lynx is one of Colorado's three native species of wild felines (cats)—the others being the mountain lion and the bobcat. It's easy to distinguish a lynx from a mountain lion. Lynx weigh about 20-to-30 pounds; lions weigh about 130 pounds. Lynx have short, "bobbed" tails, and mountain lions have graceful, black-tipped tails that are nearly three feet long.

On the other hand, telling a lynx from a bobcat can be pretty difficult if you don't know what to look for. Both are about twice the size of a domestic cat, have



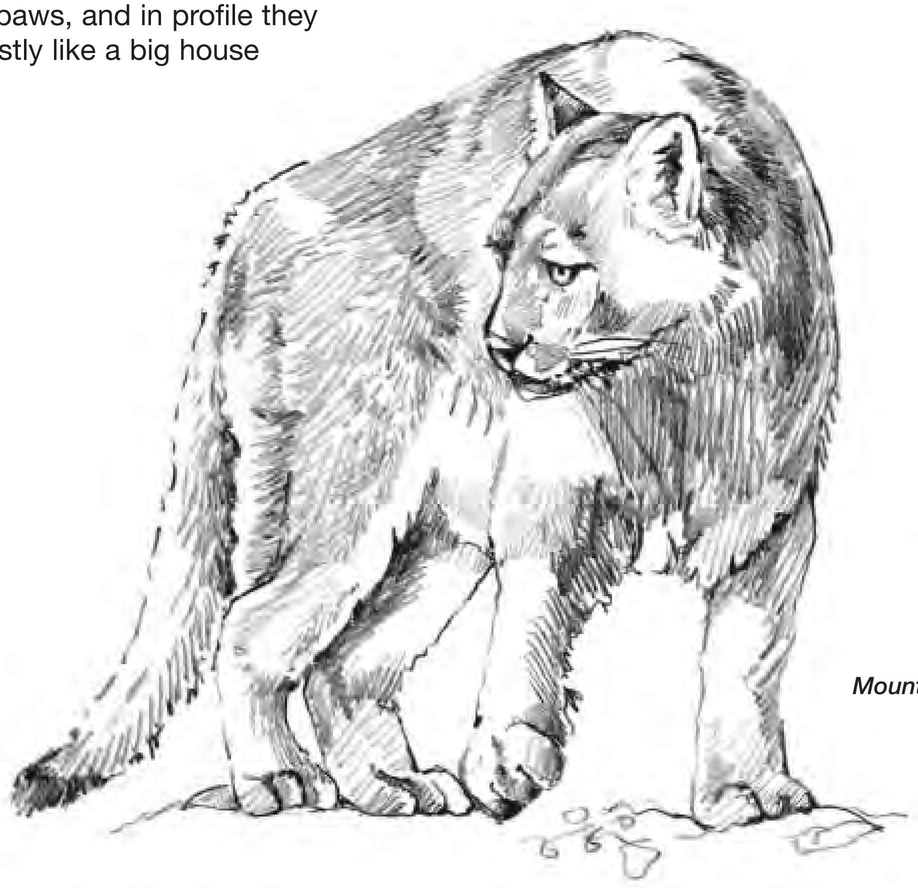
Bobcat

bobbed tails, and tufts of fur on the tips of their ears. But the two cats do have some noticeable differences! The tip of the tail on a lynx is completely black, as if the tail had been dipped in ink. The tip of the tail of a bobcat has a black spot on the top and is white underneath, and the bobcat's tail will often have several black stripes. Lynx typically have long, thick fur that is uniformly grayish-brown in winter, and shorter and more reddish in the summer. They lack distinct spots and striping. In contrast, bobcats will typically have distinct spotting on their coats and striping on their front legs and faces.

The most conspicuous difference between lynx and bobcats are in the paws. Lynx feet are huge and look out of proportion to the rest of their body—like furry clown feet! Bobcats have much smaller paws, and in profile they look mostly like a big house cat.

The History of Lynx in Colorado

Lynx sightings have always been rare in Colorado. Perhaps this is because this secretive cat lives in areas where most people don't usually travel, or perhaps they have never existed in large numbers. A 1911 report, "A Biological Survey of Colorado," referred to lynx as "tolerably common" in some parts of the state, but mentioned that "its numbers are rapidly decreasing." Prior to the reintroduction program, only 18 authenticated records of the species existed in the state and 14 of those occurred between 1878 and 1935. The remaining four documented records, between January 1968 and February 1973, all occurred in the central mountains within a 35-mile radius of Hoosier Pass,



Mountain Lion

south of Breckenridge. The last known lynx in Colorado was illegally trapped and killed on the Vail ski area in February 1973.

Colorado Division of Wildlife (DOW) biologists began to wonder if any lynx remained in the state. Between 1979 and 1998, researchers conducted 12 investigations in Colorado to document the presence of lynx. Intensive efforts—using snow tracking (5,833.5 miles), hair snags (62 locations), remote cameras (110 locations) and snares (686 trap nights)—yielded only 11 sets of tracks with a high probability, but not absolute certainty, of being lynx.

From 1993 until the start of the lynx reintroduction program in 1999, the DOW offered a $500 reward for positive information on lynx, but never paid out any money. Researchers concluded that if any lynx remained in Colorado, their numbers were so small they did not represent a ***viable population*** and were not detectable by known ***census methods***. It was quite possible that lynx had been ***extirpated*** from Colorado.

So, what's this Colorado Division of Wildlife?

Since the founding of the United States in 1776, wildlife has always been considered a public resource. Unique among nations—in the new democracy, wildlife belonged to the people, not the king.

In the early years, wildlife was abundant and new settlers made use of animals in whatever way they could. Some species were hunted for food, while others were collected for fur, feathers, or other valuable parts. Some species, particularly large predators such as wolves, lions, and bears, were eradicated because they posed a threat to human life or competed with humans for resources.

As time passed, wildlife populations began to dwindle and concern grew for the long-term well being of wildlife populations. People began to pass laws to regulate the harvest of wildlife and study the best methods to sustain wildlife species. The field of wildlife management was born. ***Wildlife management*** is defined as the application of scientific knowledge and technical skills to protect, preserve, conserve, limit, enhance or extend the value of wildlife and its ***habitat***.

Each state was given jurisdiction over most of the plants and animals in its state. Most states typically have a Department of Natural Resources that oversees all the ***natural resources***—that portion of the environment upon which people have placed or assigned value or see as being available for use. In Colorado, the Department of Natural Resources is divided into eight smaller agencies or "divisions" that manage minerals, state lands, parks, oil and gas, forests, water, and wildlife. Since 1897, the Colorado Division of Wildlife has had the responsibility to manage wildlife as a public trust, for all the people of the state.

Some Tools of Wildlife Management

Wildlife agencies employ trained biologists and other specialists who design and carry out ***management plans*** based on the needs and desired outcomes for a given species. They have a variety of techniques and tools they can use to maintain wildlife populations at optimal levels. Some examples are:

- ***Population monitoring***—estimating the number of individuals of a species either directly (by counting individual animals) or indirectly (through evidence such as tracks, scat, or nests);
- ***Habitat analysis***—identifying the key needs of the animal in question (food, water, shelter, space);
- ***Habitat protection***—passing laws that protect key habitat for the species;
- ***Protection***—passing laws that make injuring or killing that species a crime;
- ***Habitat improvement***—adding or improving key components of the species' habitat;
- ***Education***—providing information to the public about wildlife habitat and needs.

Some management techniques apply only to ***game animals***—animals that people can legally hunt, trap, or fish. These include regulations that:

- Set ***seasons***—establishing certain times of year people may hunt or fish;
- Issue ***licenses***—issuing a certain number of licenses or permits to hunt a certain species or a certain sex of that species;
- Set ***bag limits***—allow only a specified number of fish or animals to be harvested within a certain time limit;
- Set ***size limits***—usually for fish, specifying a minimum or maximum weight or length of a species that may be caught.

Law enforcement goes hand in hand with other wildlife management techniques. Many college educated biologists in wildlife agencies are also highly trained law enforcement officers. In Colorado, these special biologists are known as ***District Wildlife Managers*** or ***DWMs***. While their emphasis is on enforcing wildlife regulations, Colorado's DWMs have the same training and authority as all other peace officers in the state.

Most wildlife management plans include public input and include specifics about when, where, and for how long any management strategy will be used. It is really important to identify what the plan hopes to achieve and to identify any potential negative effects from the plan.

Special Management Cases

Marine mammals, and migratory species such as songbirds and waterfowl, are under the jurisdiction of a federal wildlife agency, the ***U.S. Fish and Wildlife Service (USFWS)***, because they cross state and/or national boundaries. The DOW also does not have jurisdiction over species that are nationally threatened or endangered. However, the DOW actively manages these species (except marine mammals—Colorado has none) in partnership with the USFWS.

Lists

Actors strive to get on the "A" list and businesses work hard to make the "Fortune 500." But there are lists no one wants to be on—state or federal threatened or endangered species lists. A wildlife species with ***endangered*** status is in immediate risk of becoming ***extinct*** (eliminated) in all or a large portion of its range. ***Threatened*** species are not in immediate peril of extinction, but are vulnerable because they exist in small numbers or in such a limited range that they may become endangered.

Both the state and federal government also maintain a list of species that may be at risk of becoming threatened or endangered. At the state level, this is the list of ***species of special concern***. At the federal level, these species are often ***candidate species*** for possible listing.

Recovery Plans and Reintroduction as a Management Technique

The ***Endangered Species Act*** is a federal law passed in 1973 that protects plants and animals from becoming extinct in this country. When a species is placed on the federal threatened or endangered species list, the federal government, through the U.S. Fish and Wildlife Service, supersedes the state's authority to manage that species. Species that are only on a state's threatened or endangered species list are still managed by that state's wildlife agency.

The Endangered Species Act of 1973 requires the U.S. Fish and Wildlife Service and the states to develop ***recovery plans*** for threatened and endangered species. Species are considered "***recovered***" when they can be taken off the list—when their populations are large enough and healthy enough to be self-sustaining in the wild.

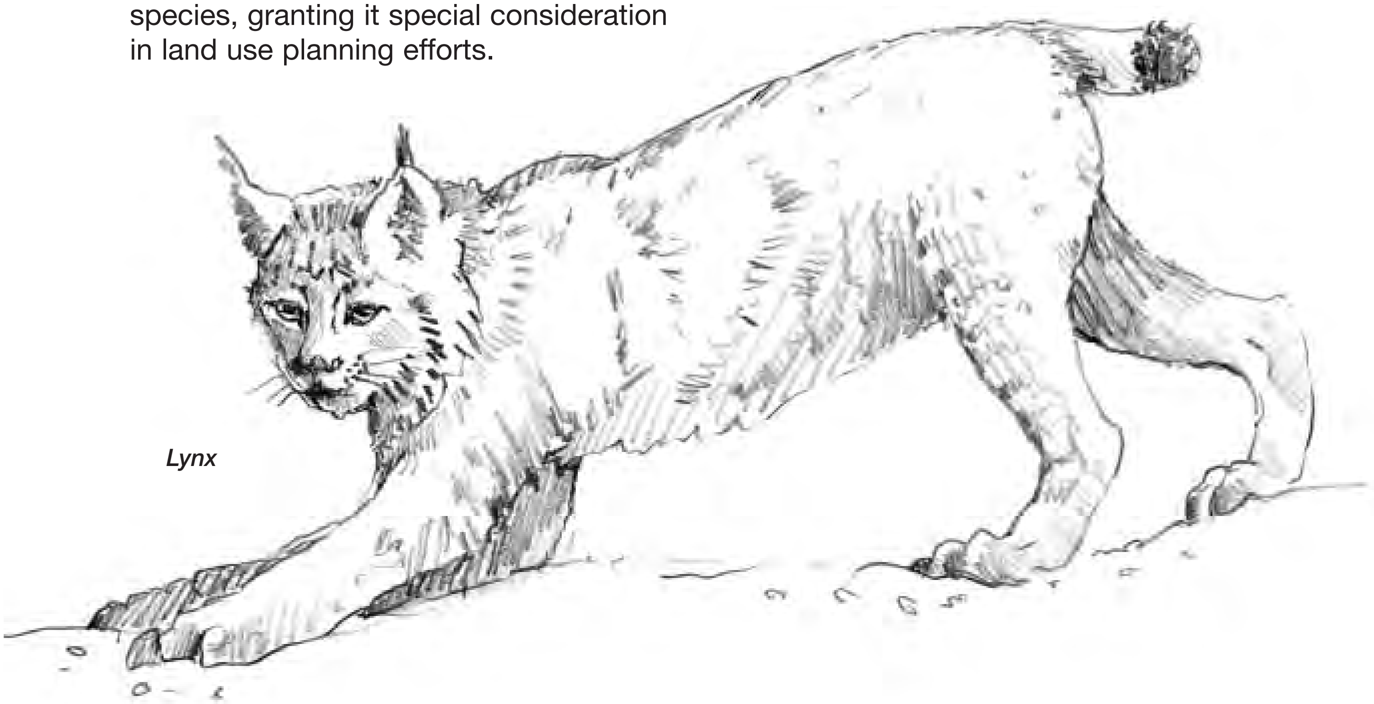
Recovery plans, like all other wildlife management plans, make use of different options and techniques. One option is ***reintroduction***, an attempt to re-establish a species in an area that was once part of its historical range, but from which it has been extirpated. Reintroduction is one of the more extreme and costly recovery options, and is chosen only when certain conditions are met and after a rigorous scientific and public review.

The Lynx Link

Efforts to protect lynx populations in Colorado began in the early 70's. First, the hunting season on lynx was closed. Lynx were designated a state endangered species in 1976 by the Colorado Wildlife Commission (the Colorado Wildlife Commission is responsible for state listings while federal classification is made by the Secretary of the U.S. Department of the Interior). A petition to list lynx as a federally endangered species in the ***conterminous 48 states*** was filed in the state of Washington, but the listing was denied in 1992. In 1993, the U.S. Forest Service designated lynx as a sensitive species, granting it special consideration in land use planning efforts.

In 1997, by order of U.S. District Court, the USFWS was required to review their decision not to list lynx. Upon review, they issued a finding of "warranted but precluded." That meant they found scientific evidence for concern and the lynx was a candidate species.

Since studies could not conclusively demonstrate that lynx still existed in viable numbers, and with the lynx a candidate to be put on the federal threatened species list, DOW biologists began formulating a recovery plan. Given the isolation of Colorado from the nearest northern lynx populations, biologists from the DOW and other experts determined that reintroduction was the only practical option for recovering the species in our state. Re-introduction of lynx began in 1999. In March 2000, lynx were officially listed as threatened in the conterminous 48 states by the USFWS.



Lynx

Lynx Links—Terms

Reading scientific reports or textbooks can be like trying to read material in a foreign language. The world of science, including the world of wildlife biologists, has a language all its own. If you are reading scientific material and cannot understand a word, you may not be able to understand the concept that goes with it.

Usually, in educational materials such as this, the writer will "flag" a new term that he or she thinks may be unfamiliar to you and define it. An example of this is the sentence, "***Wildlife management*** is defined as the application of scientific knowledge and technical skills to…" The new term is in bold letters and the word "defined" is in the sentence and it is obvious that a term is being defined.

Sometimes, however, the writer is forgetful, or possibly thinks that the word is a familiar one that anyone would understand. Or, perhaps, you may be asked to read a scientific article that was not primarily written for students and none of the words are defined. What do you do then? Your first instinct may be to look in the dictionary. Usually, that is a very good idea. Common scientific terms are often in dictionaries. But some aren't. Sometimes, you can look at the sentence more carefully, look at how the word or term is used and come up with a working definition yourself. The new word may sound like a word you already know and will be somewhat similar in meaning.

There are five ***bold words*** in the material that you just read that the author (who, for his or her protection from frustrated students, will not be identified at this time) deliberately did not define.

Without using a dictionary, see if you can figure out the meaning of these words and write a working definition of them:

Viable population

____

____

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____

Census method

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Extirpated

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____

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Habitat

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Conterminous

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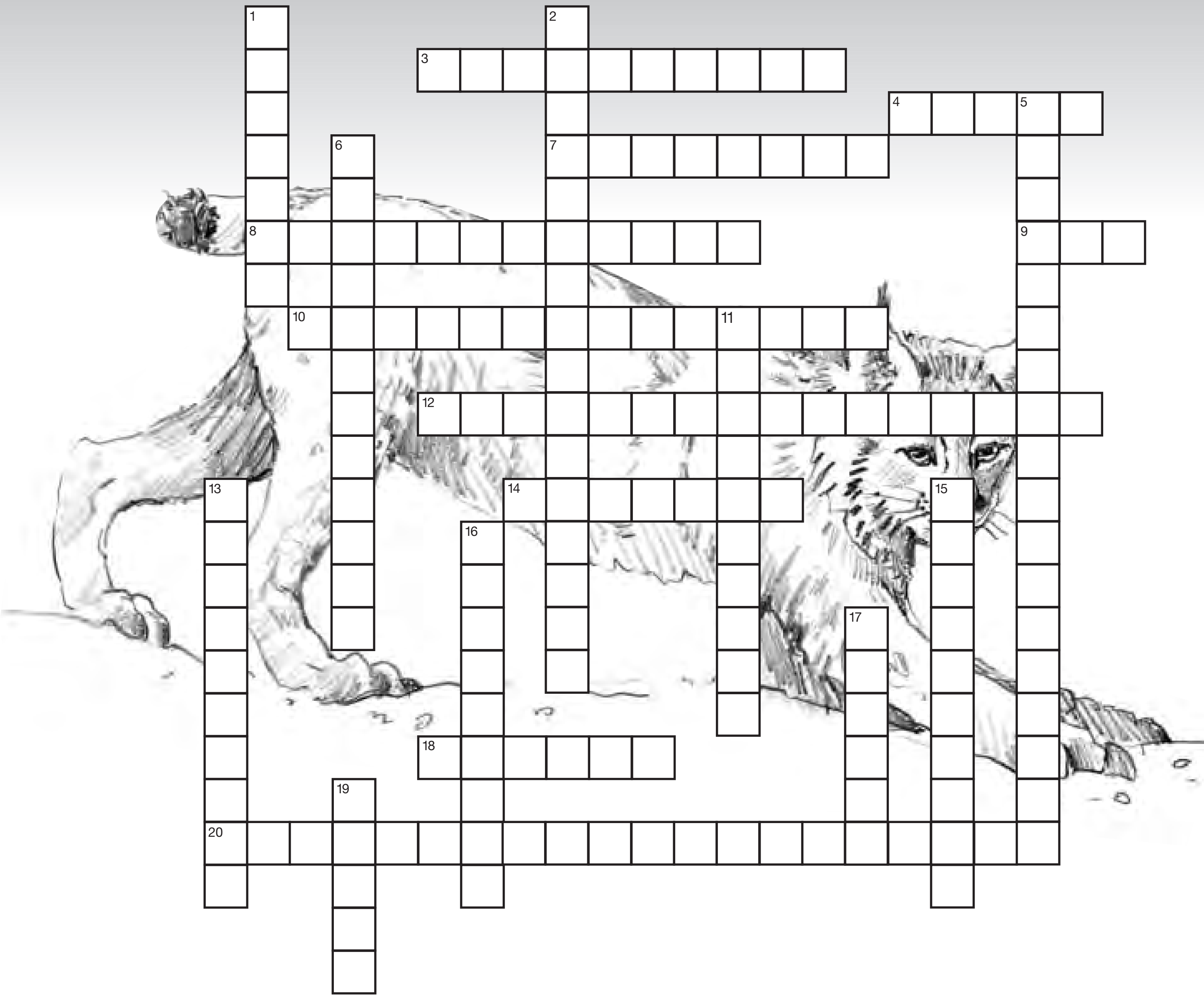
Now that you think you know what these words mean, try the crossword puzzle on the next page. Each answer is one of the ***bold terms*** in the reading.



Across

3. A species that has been eliminated from part of its historical range
4. Agency responsible for managing migratory birds, marine mammals and federally "listed" species
7. The number of a species that can be harvested in a specified period of time
8. Method to count members of a population, part of population monitoring
9. A special Colorado biologist who is also a law enforcement officer
10. An attempt to re-establish a species in an area that was once part of its historical range
12. That portion of the environment that people have assigned value to or use
14. The arrangement of food, water, shelter and space suitable to an animal's needs
18. The time of year one can hunt or fish
20. A 1973 federal law that protects animals and plants from extinction in this country

Down

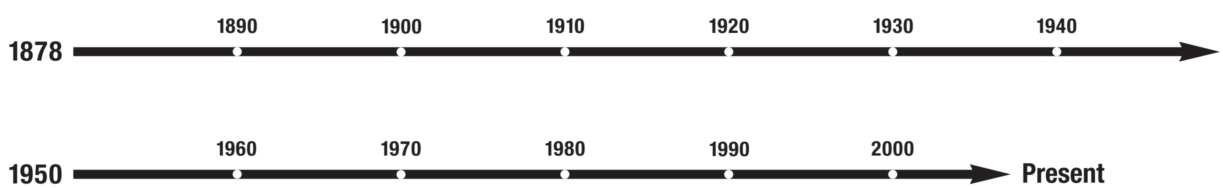
1. A species that no longer exists on this planet
2. Population that is large enough and healthy enough to be self-sustaining in the wild
5. The application of scientific knowledge to sustain wildlife and its habitat
6. Enclosed within one common boundary
11. Species that are vulnerable because they exist in small numbers or in a limited range
13. A species that is in immediate danger of becoming extinct in all or a large portion of its range
15. Animals that people can legally hunt, trap or fish
16. When a species population is large or healthy enough to be taken off the "list"
17. The owners of wildlife in the United States
19. The geographic region where a plant or animal species normally lives

Time

Time is important in scientific writing, just as it is in your life. Most people cannot organize their lives or make sense of the world without talking about time. Think about it for a moment. Could you even describe your life without time? If you tried to tell a friend what you did yesterday, you might have to mention breakfast, lunch, or supper. You may have been late or early to an event. All the underlined words reference time, as do young, old, day, night, month, year, first, last….well, you get the picture.

Time is used in scientific writing in the same two ways that it is used in life. *Chronological time* is used for describing historical events and developments, such as describing what you did yesterday or describing the history of the events that led to the decision to reintroduce lynx to Colorado. *Process time*, on the other hand, describes the sequence of a process, such as how to bake a cake or how cells divide.

There were many dates and events mentioned in the material that you just read. On your own paper, sketch out a timeline which includes all these dates and events, beginning in 1878 and ending in the "present."



Cat Comparison

Another important way to understand things is by comparing them to other things. How can you say that something is large or hairy unless you have some idea what large or hairy means? How large? Bigger than a bread box? Bigger than a freight train? How hairy? More hairy than an earthworm? A gorilla? Sometimes descriptions only have meaning when they are compared to something else.

Ultimately, there are two ways to compare things. Things are either alike or they are different. (This anonymous author now imagines eyes rolling and the word “duh” being uttered by the reader—but stick with me a moment). In life, when you have a decision to make—like purchasing shoes or deciding between social events—comparing the situation to a past experience can help make your decision easier.

Using what you already know and have experienced is also helpful for comparing things and situations in science. In fact, most scientific endeavors, such as identifying, describing, defining, and classifying, are based on your finely tuned ability to make comparisons.

We usually compare things based on their ***features***, some aspect or characteristic. For example, you might choose friends based on their height (short or tall), social competence (outgoing or withdrawn), or interests (sports or chess). This reading compared the features of the three native felines in Colorado. Set up a table similar to the one below to compare them based on features that each has. You choose which features are important.

	FEATURE					
LYNX						
BOBCAT						
MOUNTAIN LION						

Lesson 2

Educator's Overview

Planning The "Purrrfect" Comeback

Summary

After discussing factors that shape a reintroduction effort, students retrieve archived press releases on a Web site to document successful historic species' reintroduction and recovery efforts in Colorado.

Duration

One or two 45-minute class periods

Vocabulary

Competition

Habitat

Home range

Limiting factor

Niche

Learning Objectives

After completing this activity, students will be able to:

- List seven general questions which must be answered before a species reintroduction effort can begin.
- Search the Colorado Division of Wildlife's Web site for information published in any DOW press release dated from January 1996 until the present.
- Provide an example of one native Colorado species that has been reintroduced to the state, the major reason(s) for the decline of that species, and the events/changes/laws that occurred that enabled the species to recover.

Background

Many wildlife species are managed by humans, in hopes of keeping populations self-sustaining for future generations. Various measures, from setting hunting seasons, to habitat improvement, to protection, are designed to control the numbers and range of wildlife. While each species management plan is unique and designed to avoid any decline of the species, few involve the intense human effort and financial resources of a species reintroduction program. Usually, reintroduction programs are a "last resort," designed to halt and reverse a precipitous drop in a species population. While reintroduction programs are used to attempt to prevent extirpation or extinction of species, it is *important to emphasize* that worldwide, 60 percent of animal extinctions are due to *habitat loss*. Therefore, the best long-term strategy for species conservation is habitat conservation.

It is difficult to keep current on most scientific issues, and wildlife management is no exception. By the time most textbooks are published, the information in them is already dated. However, timely information is often available on the Internet, through government agencies, universities, and other credible scientific institutions. This activity introduces students to a Web site where they can find current information on wildlife in their state. Since the lynx reintroduction program is presently underway, and there are new developments in the program all the time, activities in this module will employ the DOW Web site to keep both these materials and students up to date.

Teaching Strategies

1. Thoroughly read the student materials for *Planning the "Purrrfect" Comeback*.

2. Give each student just the reading packet. Do not hand out the Internet activity.

3. After giving students sufficient time to read the packet, tell students that they are playing the role of members of the Lynx Reintroduction Planning Team.

4. As a class, brainstorm a list of questions that the "Lynx Team" must answer before they can start this effort. Use the larger questions in the reading as a start. Some possible responses are:

What are the specie's critical needs and limiting factors?
What habitat do lynx prefer?
What do lynx eat?
What was the historic range of lynx in North America and in Colorado?
What other species compete with lynx for food or other habitat components?
Why did lynx decline in the first place? Have those factors been addressed?
Have any other species filled the void created by the missing lynx?
What else lives where the lynx lives? What other species eat the same prey?
Will the lynx have too much competition?
What other environmental variables need to be considered?
Has/will Colorado's drought have an impact on lynx? What about recent forest fires?
Are there suitable release sites?
Is there enough lynx habitat left in Colorado? How do people feel about lynx? Is there a safe area to release them?
Where will we get lynx for reintroduction? How will we know they are similar to native lynx? *Where are healthy populations of lynx? How will we get them here?*
What's our plan? How will we monitor our reintroduction? How will we know if/when we've succeeded? *What would be an optimal population of lynx in Colorado? How can we tell when we have that many?*

5. Write all suggestions in a visible place. Ask students to copy these questions for future use.

6. Now distribute the Internet assignment. Depending on your school's resources, have students complete the assignment in class, a computer lab, in their local library, or at home. Allow enough time for students to complete the assignment.

7. In class, ask for students to volunteer to present information on the nine species mentioned in the press release. *What contributed to the loss or decline of the species? What has helped the recovery of the species into its historic range?* List the reasons for decline in a visible place.

Materials and Preparation

- *Access to the Internet (from classroom, school computer center, local library, or home)*
- *Student Reading and Activity Pages for* Planning The "Purrrfect" Comeback*, one photocopy per student*
- *White board or blackboard*

8. Point out that habitat loss was a major factor in decline of more than half of the species studied. Emphasize that worldwide, 60 percent of animal extinctions are due to habitat loss. While reintroduction efforts are important, it is most important over the long term to conserve the habitat that species need to survive.

Assessment

The groups' list of generated questions (for a Lynx Recovery Team) serves as an assessment for this activity.

Extensions

- Students can explore the U.S. Fish & Wildlife Service Web site (***http://www.fws.gov/endangered/***) for additional information on recovery plans for threatened and endangered species.
- Research other rare or declining species in Colorado. Develop a plan to bring about recovery for one of these species. *What method could be used?*

Student Activity Answer Key

Rocky Mountain Bighorn Sheep

- Major reason(s) for the decline of this species: Disease, loss of habitat.
- Events/changes/laws that occurred to enable recovery: Reintroduction.

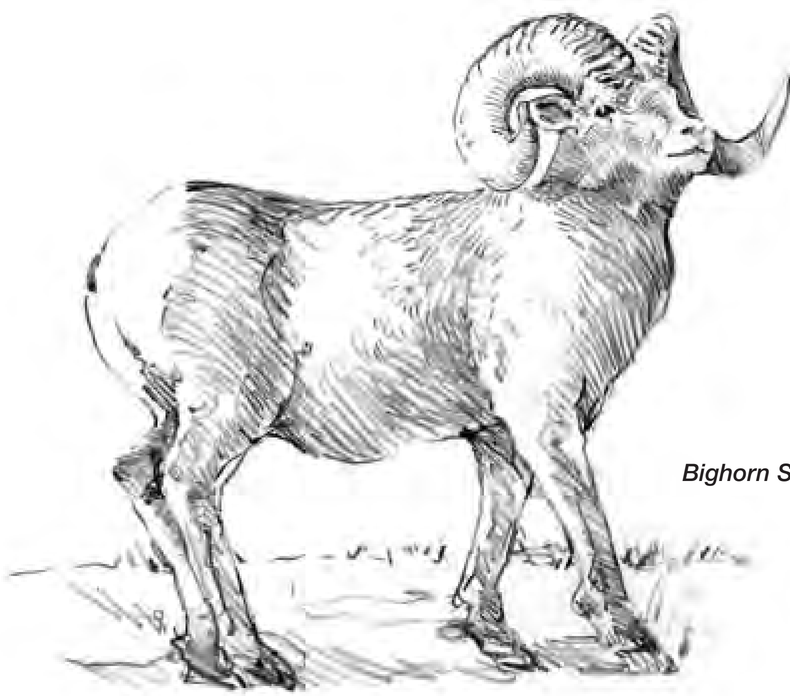
Boreal Toad

- Major reason(s) for the decline of this species: Unknown, research underway.
- Events/changes/laws that occurred to enable recovery: ***Not recovered***, captive breeding, reintroduction, and monitoring programs are underway.

American Peregrine Falcon

- Major reason(s) for the decline of this species: Thinning of eggs from pesticide DDT.
- Events/changes/laws that occurred to enable recovery: National ban of DDT, captive breeding and reintroduction.

Boreal Toad



Bighorn Sheep

Greenback Cutthroat Trout

- Major reason(s) for the decline of this species: Not mentioned in press release, but found in “Wildlife in Danger.” Overfishing, introduction of rainbow, book, brown, and Yellowstone cutthroat into their habitat, loss of habitat.
- Events/changes/laws that occurred to enable recovery: Captive breeding and release into suitable reintroduction sites, stream improvement.

Elk

- Major reason(s) for the decline of this species: Unregulated market hunting.
- Events/changes/laws that occurred to enable recovery: Two decades of hunting restrictions and importing elk from Yellowstone National Park.

Plains Sharp-tailed Grouse

- Major reason(s) for the decline of this species: Habitat loss.
- Events/changes/laws that occurred to enable recovery: Habitat improvement—planting grasses grouse like.

Lesser Prairie Chicken

Major reason(s) for the decline of this species: Loss of habitat.

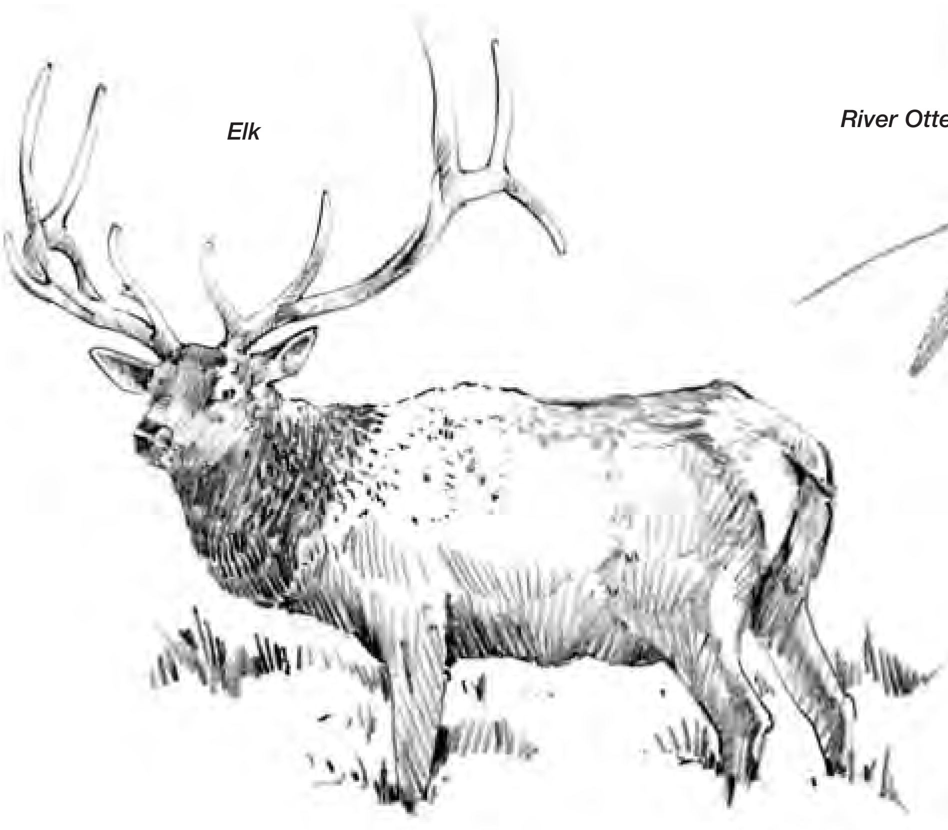
Events/changes/laws that occurred to enable recovery: Habitat improvement and preservation, landowner agreements.

River Otter

- Major reason(s) for the decline of this species: Not found in the press release. From “Wildlife in Danger”—Trapping, water pollution, and farming.
- Events/changes/laws that occurred to enable recovery: Reintroduction.

Black-footed Ferret

- Major reason(s) for the decline of this species: Not found in the press release. From “Wildlife in Danger”—Poisoning of prairie dogs, disease, loss of habitat.
- Events/changes/laws that occurred to enable recovery: Not recovered—still critically endangered. Captive breeding and reintroduction is underway.



Lesson 2: Planning the “Purrrfect” Comeback

Lesson 2

Student Pages

Planning the "Purrrfect" Comeback

A Not Quite "Purrrfect" Solution

Reintroduction can be a valuable wildlife management tool for recovering species that have become extirpated in local areas or even globally extinct in the wild. In part, reintroduction can be credited with saving many species from extinction, including the California condor, black-footed ferret, peregrine falcon, and our Nation's symbol, the bald eagle. While species reintroductions like these are impressive, reintroduction is hardly a perfect answer to the problem of vanishing species.

Reintroduction is a very complex strategy that costs millions of dollars and the time of biologists whose efforts could be directed elsewhere. Each reintroduction takes so much work that the technique should not be thought of as a universal tool for broad-scale preservation of species. Since most endangered species are in trouble because their habitat has been fragmented, destroyed or degraded, conserving and restoring habitat is usually the best way to sustain endangered plants and animals and to prevent species listing in the first place.

Under most conditions, scientists favor conserving the habitat that supports many species rather than a species by species approach. When reintroduction seems to be the best or only option, biologists do a lot of homework beforehand to make sure that the reintroduction has a high probability of success. Before the project begins, biologists have to find the answers to lots of questions.

What are the species critical needs and limiting factors?

Each species has its own ***habitat*** requirements—the arrangement of food, water, shelter and space suitable to its needs. The amount of habitat that the animal needs or travels over in the course of its daily activities—its ***home range***—may depend on its social behavior and whether it is solitary or travels in groups. *Is there enough habitat left to support a breeding population?*

Limiting factors are components of the environment that keep an animal from surviving or reproducing, like diseases or predators or lack of food. *Are limiting factors so severe that there would be more animals dying than surviving if they were reintroduced?*

Why did the species decline in the first place?

To be sure the reintroduction is successful, biologists must make sure that the main cause(s) of the original extirpation are gone. *What caused the demise of the population? Disease? Unregulated over-hunting? Over-collection? Pollution? Poisoning? Too much* **competition** *(demand for limited resources)? Predation by introduced or native species? Habitat loss? Adverse effect of an earlier management program? Conflict with human activity? Have there been changes in the original events or new regulations that will now allow the species to recover?*

Have any other species filled the void created by the extirpated species?

Every animal has its own ***niche***—its role or function in an ecological community. Sometimes when a species is eliminated from an area, there is no species to take that role and there are dramatic changes in the habitat. For example, a golden eagle is a predator that hunts rodents. If all the golden eagles were extirpated from an area and no other species took its place, rodent populations may grow so large that they eat all the vegetation. On the other hand, other species that eat rodents, such as hawks and snakes, may come in and fill this niche. If many other species filled this role, there might be too much competition for a successful reintroduction of golden eagles.

What other environmental variables need to be considered?

Is climate a factor? Is there an ongoing drought that reduces the food supply? Are there highways criss-crossing an area where a reintroduction is being considered? Are invasive species that were not historically in the area a threat?

Are there suitable release sites?

Is there suitable habitat within the historic range of the species? Is this area of sufficient size that the species can be sustained for the foreseeable future? How do people living near the potential release site feel about this proposal?

Is there a suitable source and availability of animals for reintroduction?

The individuals that are gathered for reintroduction should be genetically similar to the native animals and respond to the environment in similar ways. Also, it is important that removing individuals from the source population doesn't endanger that population. If the source population is captive bred, then the animals must have enough experience to survive in the wild and not be so confident in the presence of humans that they pose a danger. Once the source animals are found, they need to be screened for contagious pathogens and parasites, and there has to be a transportation plan to get them to the release site.

Do we know what we want to accomplish and have a plan to monitor our success?

Most reintroduction efforts are experimental. The reintroduction team first chooses indicators of success (i.e. optimal population level) or failure and decides what events would cause them to end the reintroduction program. Then they carefully plan their initial release strategy (e.g. timing, acclimatization of release animals, group composition and number, release pattern and technique, etc.), and design a monitoring program to track everything. Finally, the team develops education and public relations programs to inform and sometimes involve the public in the effort.

Successful Reintroductions—More than Good Science

Ultimately, decision makers need more than the best scientific input to decide whether to reintroduce a species. They need to know that there is long-term financial and political support, that there is full involvement and permission of all relevant government agencies, and that the legal requirements of both the Endangered Species Act and Colorado statutes have been met. They must also attempt to address the concerns of local citizens, identify any risks to human life and property, and identify ways to minimize these risks. Finally, they must make sure that the species will have minimal threat from human activities.

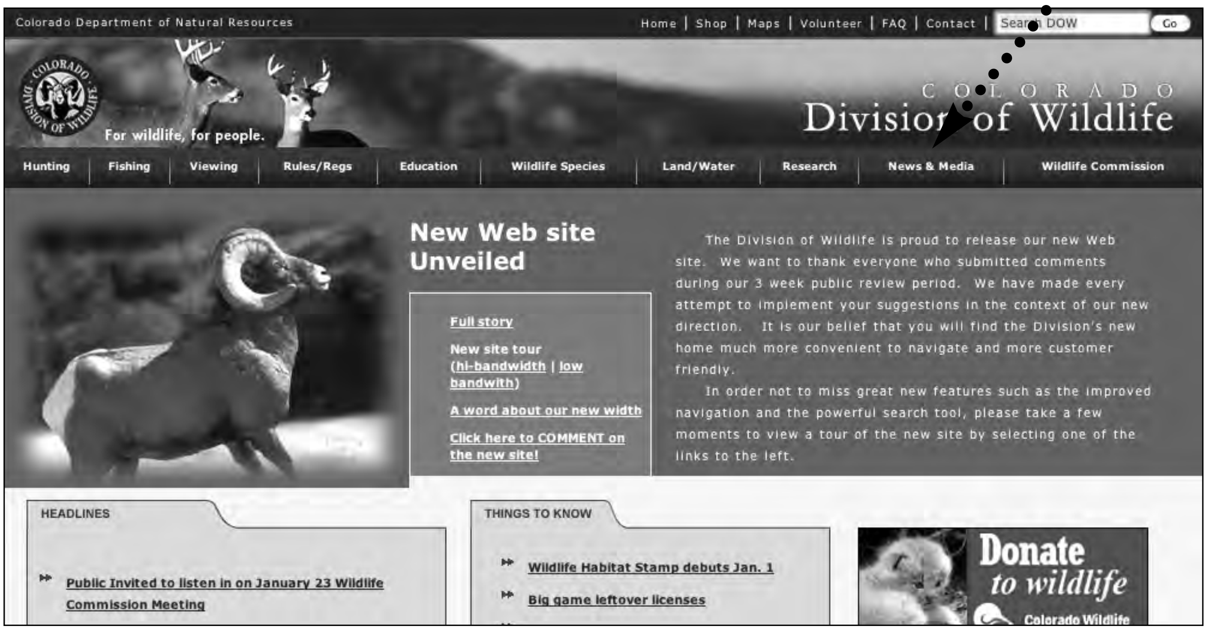
Lynx Reintroduction Team Planning Questions

Planning the "Purrrfect" Comeback for Lynx

When undertaking a task as difficult as reintroducing lynx back into historic habitat, it pays to have experience. The Colorado Division of Wildlife has had plenty! The lynx reintroduction follows many successful efforts at restoring Colorado's native species. Information about these reintroductions can be found on the Colorado Division of Wildlife's Web site.

This activity will require you to access DOW's Web site to answer a few brief questions. The Colorado Division of Wildlife is YOUR state agency, conserving YOUR wildlife. It only makes sense that YOU know how to get information about YOUR wildlife whenever you want. So, after you have answered the questions, feel free to explore the rest of the site to see what it has to offer.

To access the site, you can either type in the Web address: ***http://wildlife.state.co.us*** or you can type Colorado Division of Wildlife in the search box on your screen. Once you are at the Web site, you will notice a row just below the agency banner that looks like this:

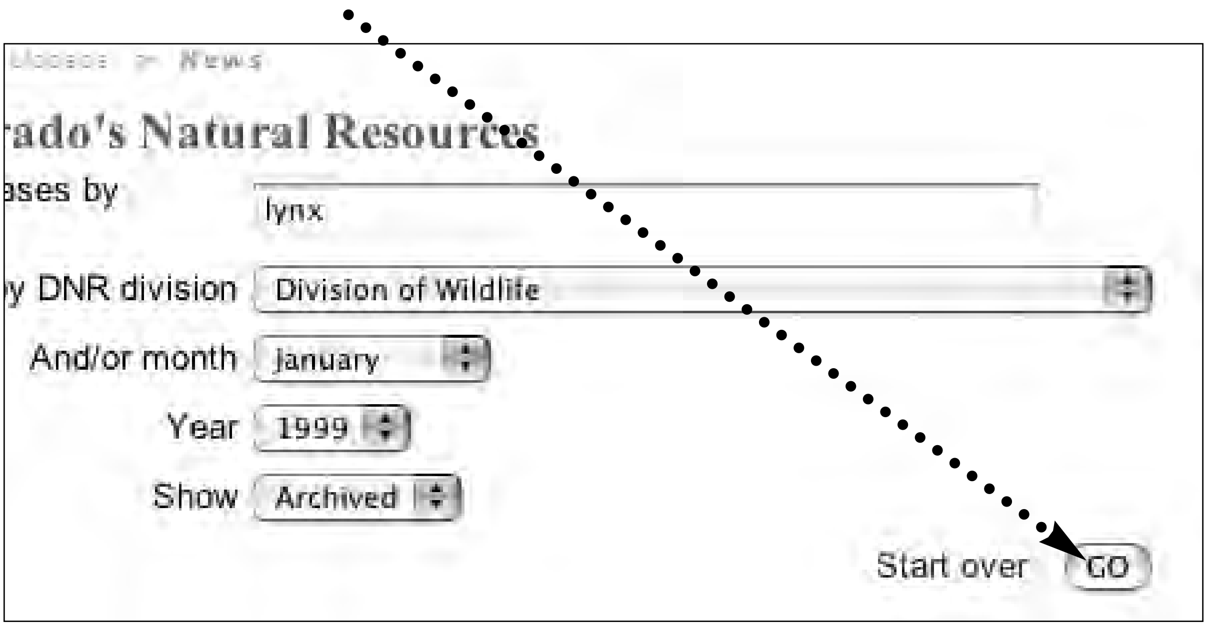


Click on "News & Media." You will then see a column on the left hand side with the following choices:

Now, click on "Press Releases."

This is what you will see:

Fill in the information as shown here and click on the “GO” button.



Click on the press release titled: ***LYNX PART OF LONG LINE OF REINTRODUCTIONS BY DIVISION*** and read it.

Date	Division	Article
1/29/1999	Division of Wildlife	VETERINARIANS TO SAFEGUARD HEALTH OF LYNX Lynx will make their way to Colorado with veterinarians looking out for their health.
1/29/1999	Division of Wildlife	AFTER 20 YEARS, TRAPPER STILL MYSTIFIED BY LYNX BEHAVIOR Despite twenty years of experience trapping lynx, British Columbia trapper Paul Blackwell remains mystified by their behavior.
1/29/1999	Division of Wildlife	LYNX WILL BE UNDER INTENSE SCRUTINY While they probably will not know it, the 50 Canadian lynx that will be reintroduced in the mountains of southwest Colorado will be under a lot of scrutiny.
1/29/1999	Division of Wildlife	LYNX PART OF LONG LINE OF REINTRODUCTIONS BY DIVISION The impending release of lynx is just the latest chapter in a decades-long endeavor to reintroduce and restore imperiled native species.
1/29/1999	Division	DIVISION PLANS LYNX RELEASE FOR FEB. 3

Then, choose just one of the species that is talked about in the press release and answer the following questions about that species. If you cannot find all your information on your species in the press release, you can click on "Wildlife Species" on the row menu beneath the banner, and then on "Species of Concern" on the left side. Then click on the "Wildlife in Danger" publication.

Species Name:

Major reason(s) for the decline of this species:

Events/changes/laws that occurred to enable recovery:

That's it! Pretty easy!

So much for history, there's a cat to bring back. Let's get started. As scientists trying to reintroduce lynx into Colorado, you've generated some questions to answer; questions that you can answer over the next week or so as you complete each lesson.

Lesson 3

Educator's Overview

Map That Cat

Summary

Students map the geographic distribution of lynx in North America based on historic lynx occurrences to gain important insights into the connection between coniferous forests and lynx occurrence in North America.

Duration

One 45-minute class period

Vocabulary

Cover type

Learning Objectives

Students will be able to:

- Map and describe the historic distribution of Canada lynx in the western United States.
- Interpret three graphs to analyze the distribution of plant cover types and lynx in Montana, Wyoming and Colorado.
- Convert a metric measurement into an English measurement.

Background

The climate of any physical environment determines what organisms live there. Life is mostly dependent on two climatic elements—temperature and moisture. Most organisms are adapted to live within a particular range of these two factors. Plants only grow in suitable climates. The animals that depend on those plants—either directly (herbivores) or indirectly (carnivores)—are found in those same climates. On Earth, similar biological communities occur in different areas, but each of these areas has similar climate and geography. This activity is designed to demonstrate that lynx prefer coniferous forests as habitat, and that these forests occur in similar climates.

Teaching Strategies

1. Thoroughly read the student materials for *Map That Cat*.

2. As a review of the previous activity, ask students how they might find out which habitat lynx prefer in Colorado and where they previously lived in the state. Someone should suggest looking at historical information.

3. Tell students that you have historic information gathered from written accounts and trapping records for the western United States. They will need to map the information.

4. Divide the class into groups of four to six. Give each group state maps and the corresponding *Lynx Sightings by State* charts.

5. Using the chart information, students should draw a small dot (about ⅛" in diameter) in the correct county on each state map for every lynx occurrence. Dots may overlap. *(**Note:** students may ask why the Colorado map and information is different from the information provided in Lesson 1—that there were only 18 authenticated records of lynx in the state. Tell them that the information in Lesson 1 included only actual specimens that were trapped, and no written records. This information includes written entries in journals and other documents that could not be verified. However, for this activity, including written records is useful.)*

6. After each group has completed their maps, ask students to assemble all the maps by taping them together. Hang the maps in a very visible classroom location. ***IMPORTANT:*** These maps are also needed for *Lesson 6, No Cat Is An Island*. Please leave the maps posted.

7. Place the acetate of the map entitled *Map of Lynx Sightings, 1842–1998* on an overhead projector. Ask students to compare this map to the maps they created. They should notice that the points for the western United States are identical, but this map includes lynx sightings in other geographic locations: the Lake States, and Northeast.

8. Now place the acetate of the map entitled *Spruce/Fir Forests in the Conterminous United States* on the overhead projector.

9. Point out that there seem to be spruce/fir forests in many areas of the United States. Explain that the forests in each region are not identical. In the western states, the species of trees include mostly Englemann spruce and subalpine fir, the same trees that are found in British Columbia and Alberta, Canada. In the Northeastern United States and Quebec, Canada, red spruce, black spruce, and balsam fir are the dominant tree species. In the Great Smoky Mountains and the southern Appalachian Mountains, red spruce and Fraser fir are the dominant species. Emphasize that he type of vegetation that can grow in an area depends on climate, especially temperature and moisture. Describe for students how temperature and moisture decrease as latitude (distance from the equator) increases. They also decrease as elevation (height above sea level) increases. In general, every degree of latitude traveling north (or south) of the equator is the equivalent of moving 360 feet higher in elevation at the equator. As a result, mountains often show the same sequence of change in ecosystems that is found as one goes north or south from the equator. You would expect to find many of the same environmental conditions in Colorado's high mountains as in lower elevations of northern Montana, and therefore, similar tree species. Since high elevations in the Southeastern U.S. have the same climate as in Maine or Quebec, Canada, many of the tree species are the same. ***Optional:*** If students' biology textbooks illustrate this concept, you may want to direct them to those illustrations.

Materials and Preparation

- *State maps and corresponding* Lynx Records 1842 to 1998 *for each of these states: Colorado, Utah, Wyoming, Montana, Idaho, and Washington, one photocopy per group of students*
- *Student Page* Lynx Sightings in Montana, Wyoming, and Colorado*, one photocopy per group of students*
- *Overhead projector*
- *Acetate transparency:* Map of Lynx Sightings, 1842–1998
- *Acetate transparency:* Spruce/Fir Forests in the Conterminous United States
- ***Optional:*** *Classroom biology texts illustrating earth's biomes and the relationship between climate and latitude/ elevation.*

10. Now place the *Map of Lynx Sightings, 1842–1998* on top of the *Spruce/Fir Forests in the Conterminous United States* map. Point out that lynx are usually seen in spruce/fir forests.

11. Now hand out the student page entitled *Lynx Sightings in Montana, Wyoming, and Colorado*. Ask students to look at the graphs and answer each question.

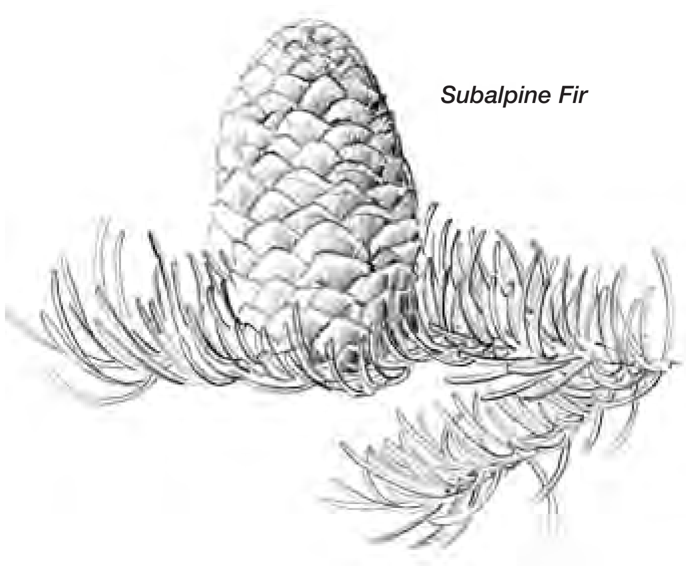
12. Ask students, "*What general statement can you make regarding lynx sightings in the Rocky Mountains related to elevation"?* Lynx sightings have been primarily in areas of high elevation. The farther south in the Rocky Mountains, the higher the elevation.

Assessment

By researching the plant cover type of any location in North America (U.S. or Canada), students should be able to state whether lynx habitat exists in that location.

Extensions

- Students could map historic worldwide distribution of lynx.



Subalpine Fir

Student Activity Answer Keys

1. Which state is farthest north? ***Montana.***

2. Approximately what percentage of Montana's landscape is 2,000 meters in elevation or less? ***88 percent (Note: Students can figure this out by drawing a horizontal line from the top of each area bar representing 2,000 meters or less to the Percent axis of the graph and adding those numbers together.)***

3. Approximately what percentage of Wyoming's landscape is 2,000 meters in elevation or less? ***49 percent***

4. Approximately what percentage of Colorado's landscape is 2,000 meters in elevation or less? ***48 percent***

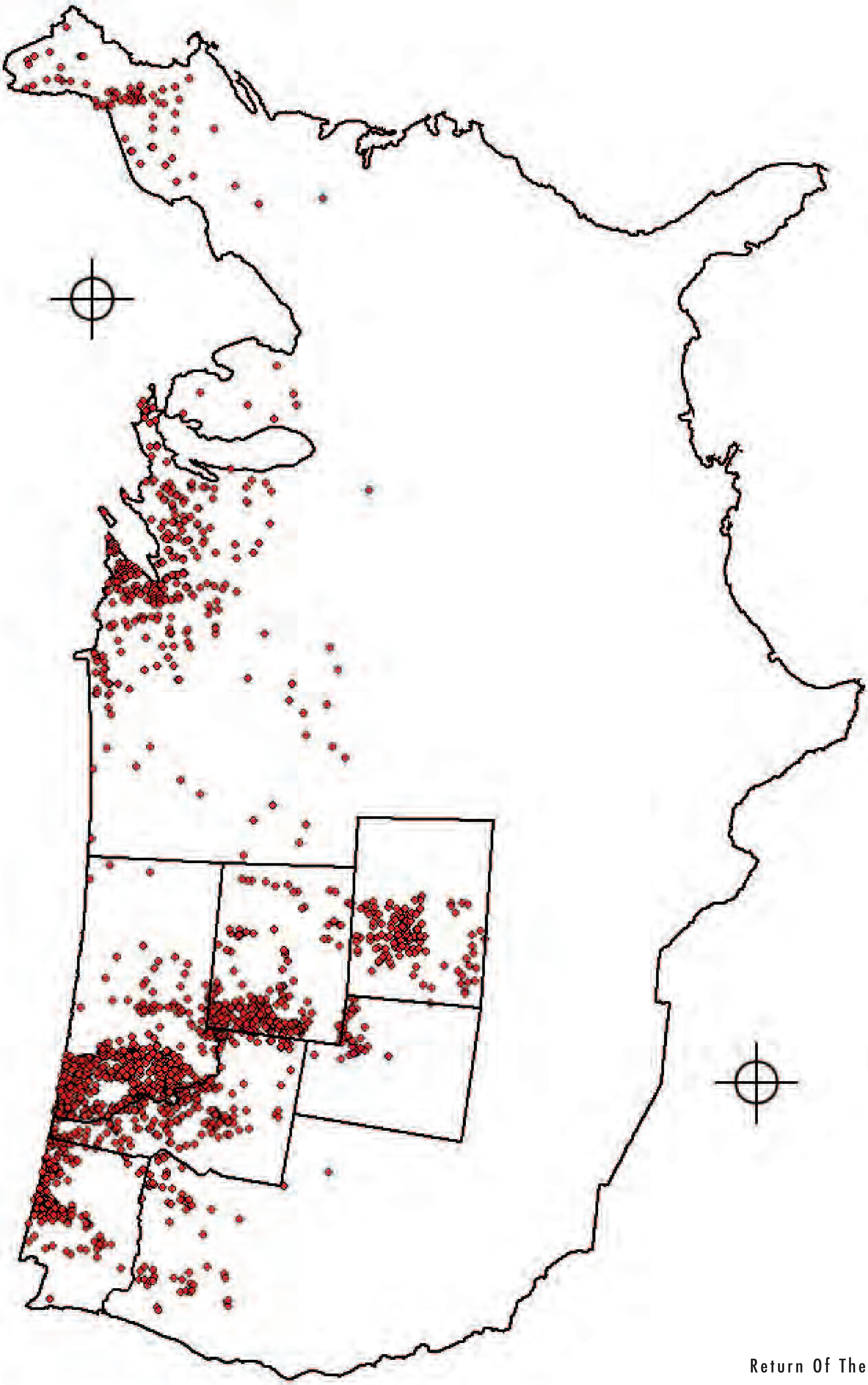
5. How high in feet is 2,000 meters? ***6,560 feet (meters x 3.28 = feet)***

6. Looking just at lynx sightings; are lynx found at higher elevations in Montana, Wyoming, or Colorado? ***Colorado***

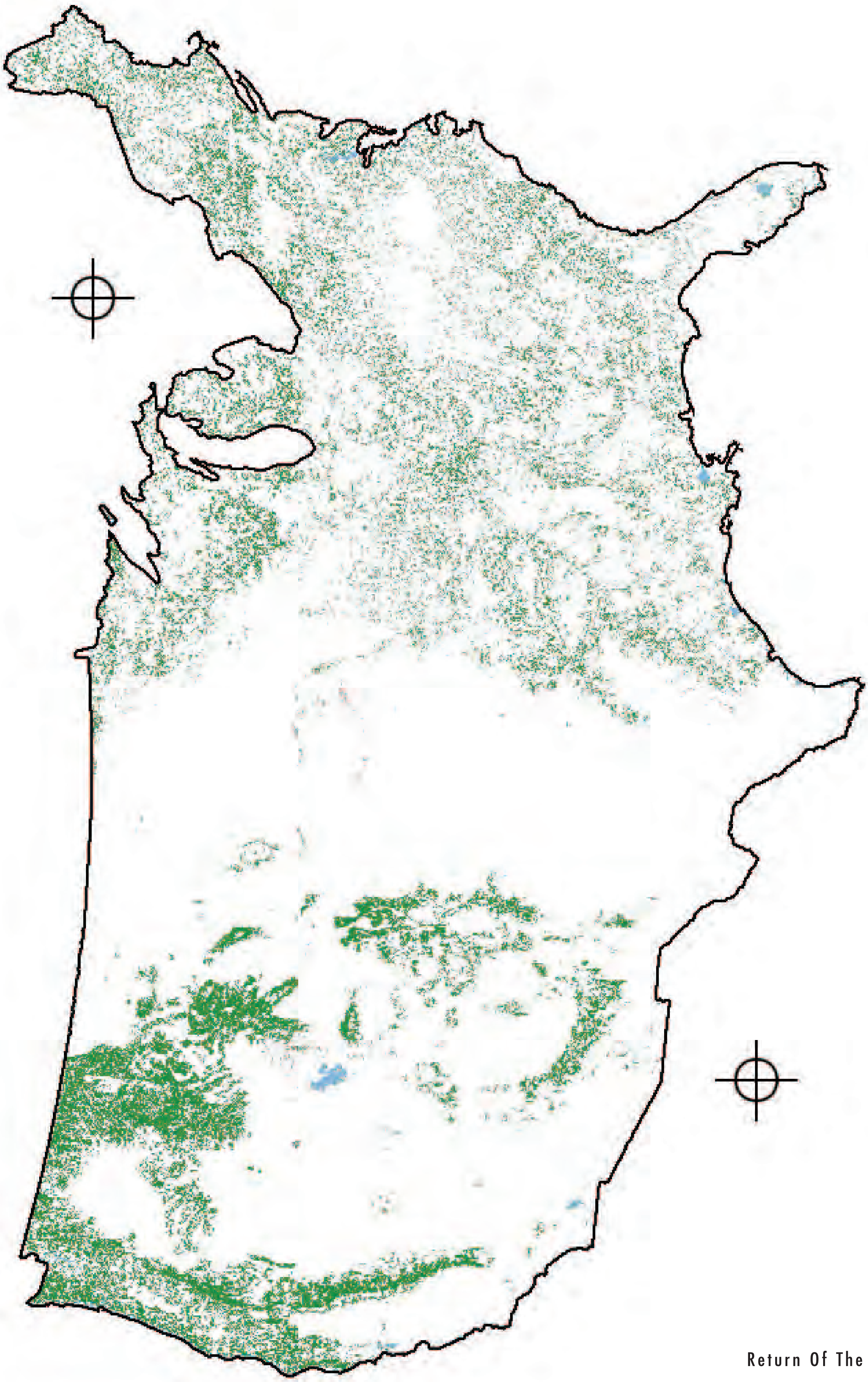
7. Would the plant ***cover type*** (type of plants found at that location) be the same at 2,500 meters elevation in each state? ***No.*** Why or why not? ***The type of vegetation that can grow in an area depends on climate. Temperature and moisture decrease as latitude (distance from the equator) increases. They also decrease as elevation (height about sea level) increases. You would expect to find many of the same environmental conditions in Colorado's high mountains as in lower elevations of northern Montana.***

8. What forest type is probably represented at the elevations where lynx sightings occur in each state? ***Spruce/Fir forests.***

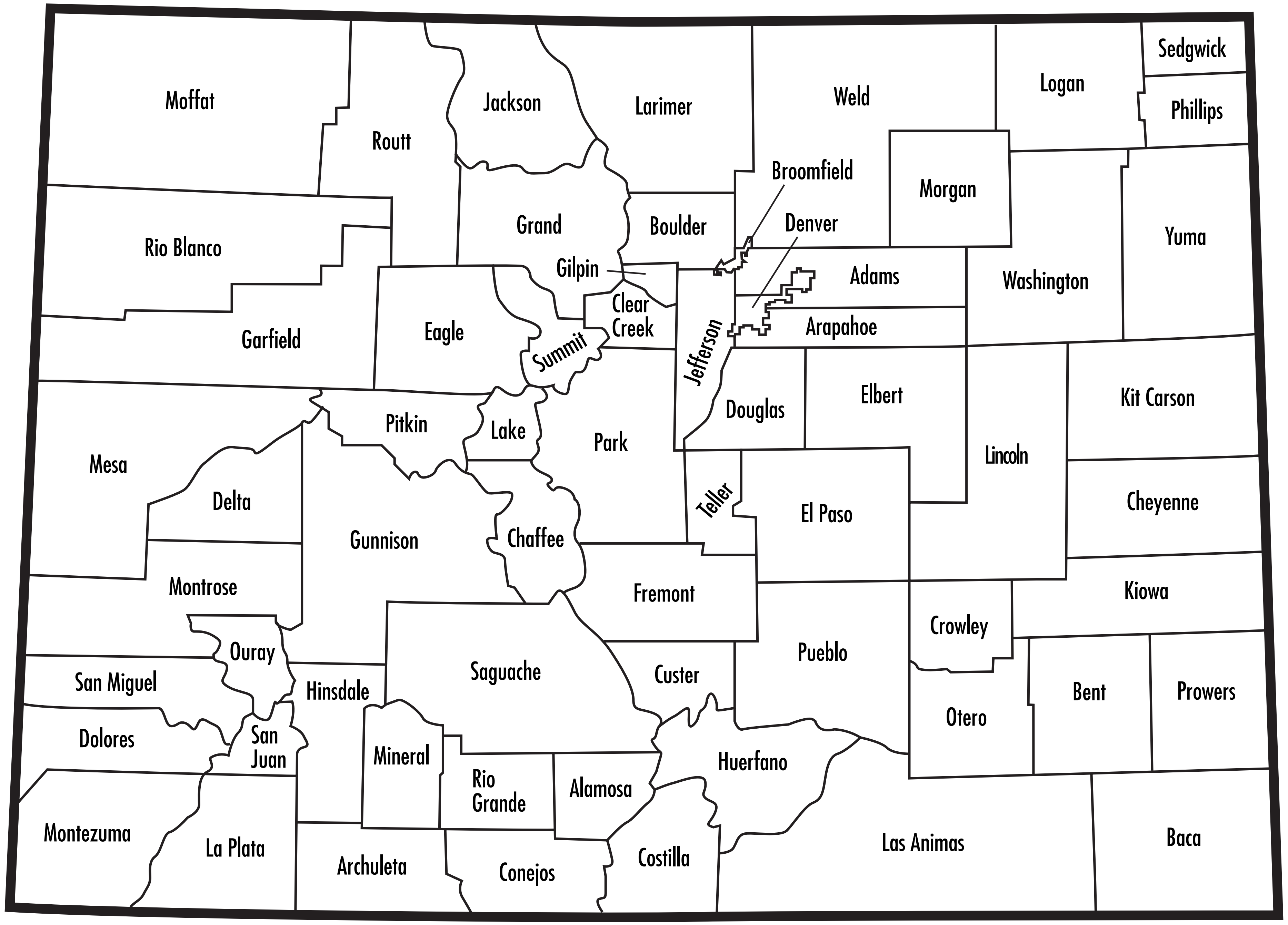
Map of Lynx Sightings, 1842–1998



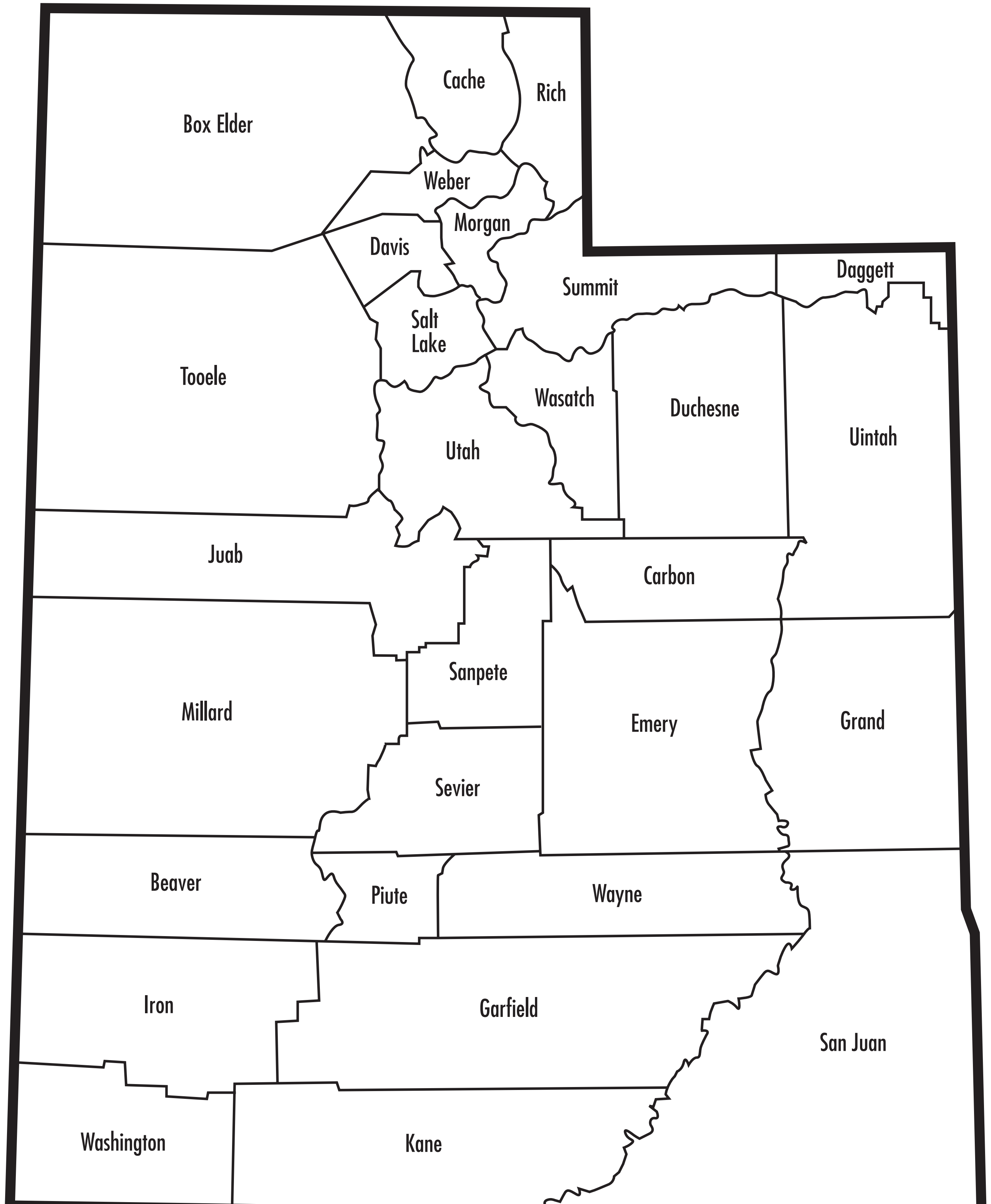
Spruce/Fir Forests in the Conterminous United States



Colorado Counties

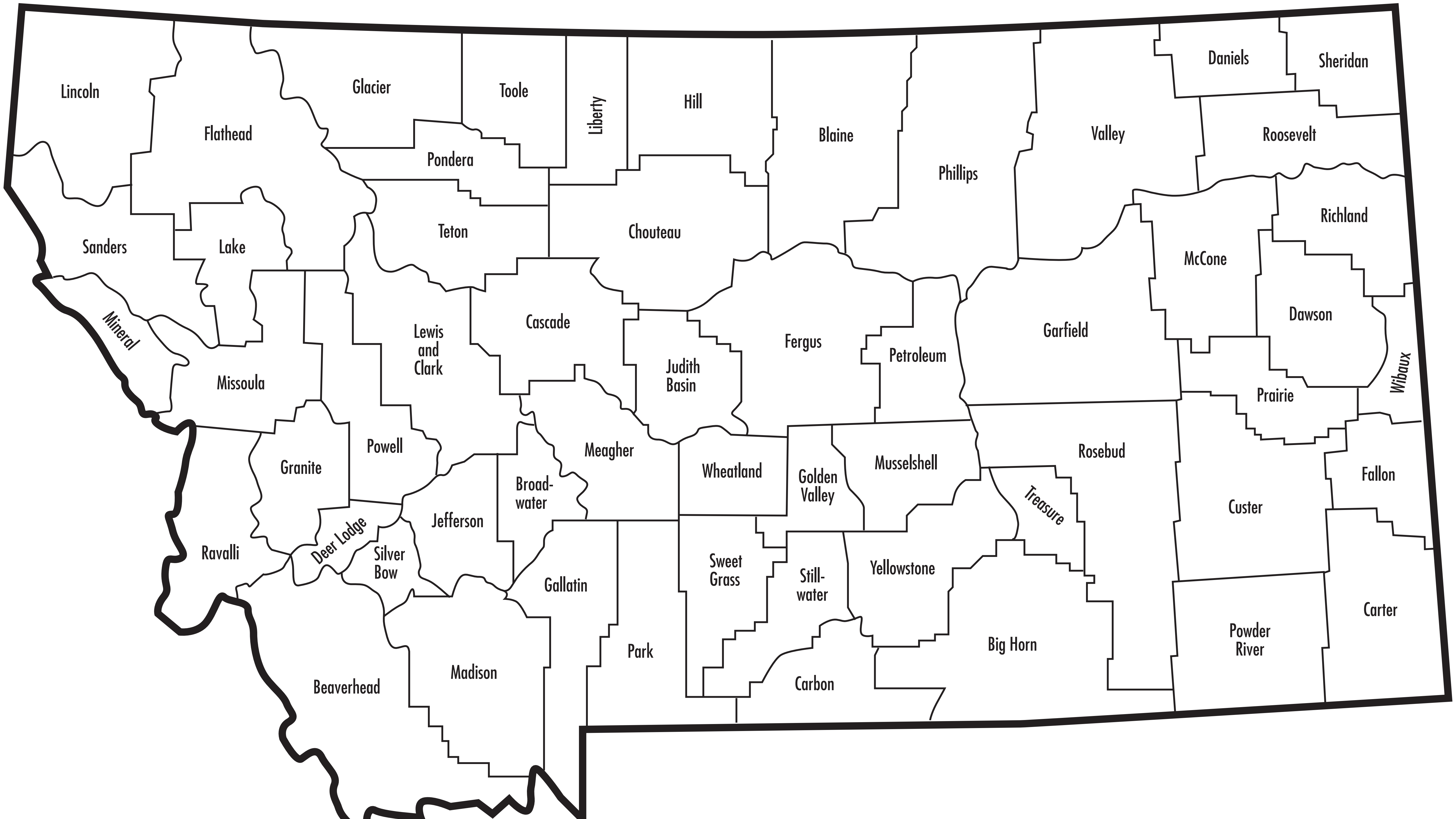


Utah Counties

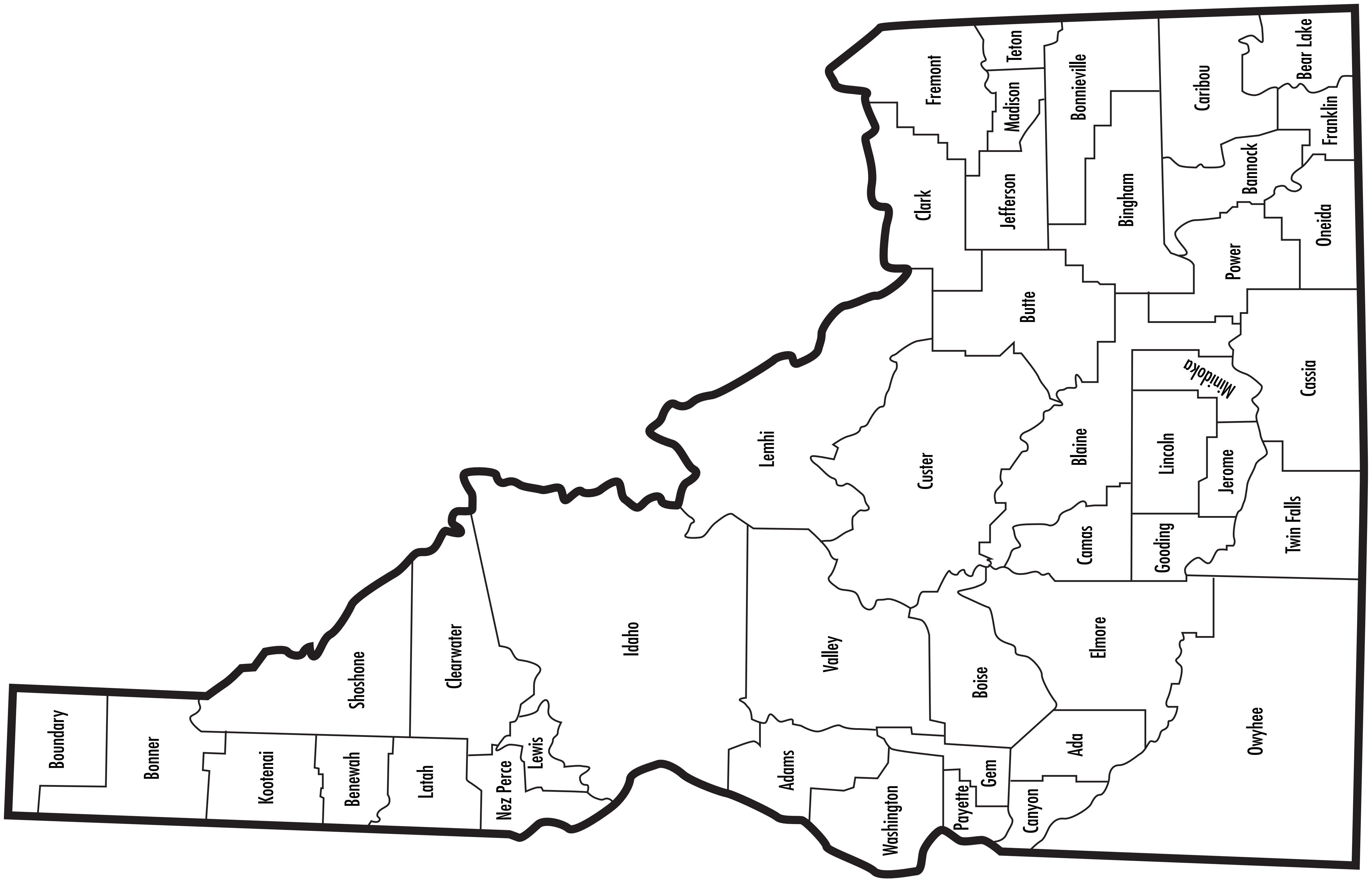


Wyoming Counties

Montana Counties



Idaho Counties



Lesson 3: Map That Cat

Washington Counties

Lynx Sightings by State

COLORADO	
County	Number of Lynx Sightings, 1842–1998
Archuleta	3
Boulder	3
Chaffee	5
Clear Creek	5
Conejos	3
Costilla	1
Custer	2
Delta	1
Douglas	3
Eagle	48
El Paso	1
Garfield	5
Grand	8
Gunnison	10
Hinsdale	1
Huerfano	1
Jackson	4
Laplata	4
Lake	3
Larimer	7
Mesa	2
Moffat	2
Montezuma	4
Montrose	2
Park	11
Pitkin	21
Rio Blanco	9
Rio Grande	1
Routt	12
Saguache	1
San Juan	2
Summit	14
Teller	1
TOTAL	**200**

UTAH	
County	Number of Lynx Sightings, 1842–1998
Cache	1
Daggett	3
Duchesne	5
Emery	1
Morgan	1
Summit	15
Uintah	9
Wasatch	10
TOTAL	**45**

WYOMING	
County	Number of Lynx Sightings, 1842–1998
Albany	3
Big Horn	2
Carbon	10
Converse	5
Crook	3
Fremont	41
Johnson	8
Laramie	1
Lincoln	57
Natrona	1
Niobrara	1
Park	39
Platte	1
Sheridan	4
Sublette	83
Sweetwater	3
Teton	70
Uinta	3
Weston	2
TOTAL	**337**

Lynx Sightings by State

MONTANA	
County	Number of Lynx Sightings, 1842–1998
Beaverhead	97
Blaine	1
Broadwater	1
Carbon	2
Cascade	6
Chouteau	2
Daniels	1
Dawson	1
Deer Lodge	32
Fergus	32
Flathead	255
Gallatin	20
Garfield	1
Glacier	68
Granite	38
Jefferson	11
Judith Basin	2
Lake	16
Lewis And Clark	134
Liberty	1
Lincoln	236
Madison	7
Meagher	8
Mineral	22
Missoula	242
Musselshell	2
Park	16
Phillips	1
Pondera	18
Powell	126
Ravalli	38
Roosevelt	1
Sanders	14
Silver Bow	14
Stillwater	2
Sweet Grass	2

MONTANA (continued)	
County	Number of Lynx Sightings, 1842–1998
Teton	108
Wheatland	1
Yellowstone	2
TOTAL	**1,581**

IDAHO	
County	Number of Lynx Sightings, 1842–1998
Bear Lake	4
Benewah	1
Blaine	7
Boise	1
Bonner	22
Bonneville	3
Boundary	5
Butte	1
Camas	2
Caribou	4
Clark	8
Clearwater	9
Custer	56
Elmore	3
Fremont	21
Idaho	41
Jerome	1
Kootenai	3
Latah	4
Lemhi	44
Nez Perce	1
Oneida	1
Power	1
Shoshone	17
Teton	4
Twin Falls	2
Valley	5
TOTAL	**271**

Lynx Sightings by State

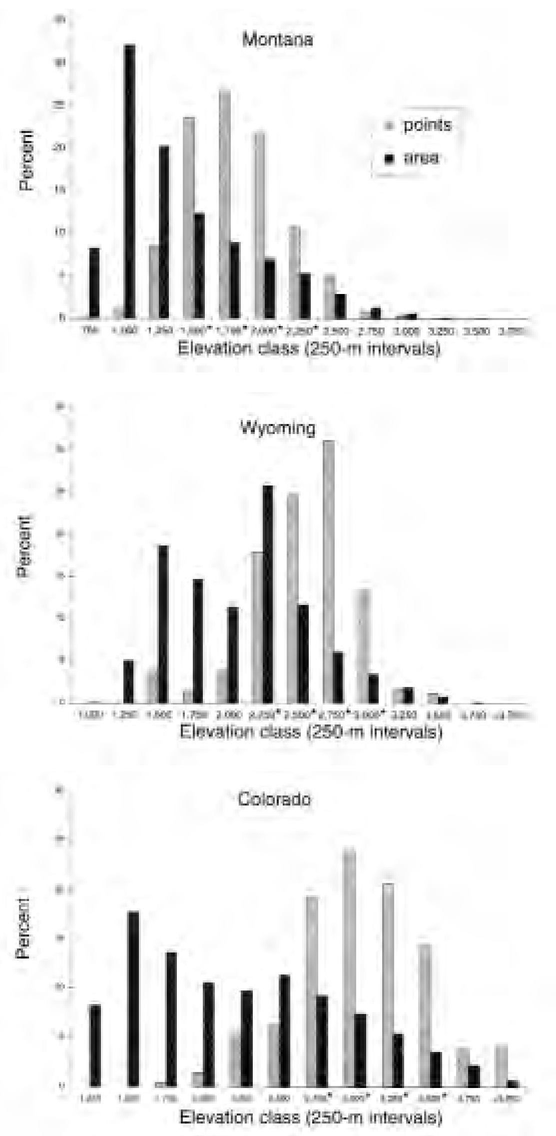
WASHINGTON	
County	Number of Lynx Sightings, 1842–1998
Chelan	64
Columbia	1
Douglas	5
Ferry	55
Garfield	2
Jefferson	1
King	4
Kittitas	1
Okanogan	501
Pend Oreille	91
Pierce	1
Skagit	2
Skamania	10
Snohomish	1
Spokane	2
Stevens	24
Whatcom	4
Whitman	3
Yakima	11
TOTAL	**783**

Lesson 3

Student Page

Lynx Sightings in Montana, Wyoming, and Colorado

Dr. McKelvey analyzed lynx sighting records by county for Montana, Wyoming and Colorado and graphed both the percentage of elevation types (area) found in the counties and the percentage of lynx sightings (points) at each of the elevations.



From *Ecology and Conversation of Lynx in the United States.* Used with the permission of Dr. Kevin S. McKelvey

1. Which state is farthest north?

____

2. Approximately what percentage of Montana's landscape is 2,000 meters in elevation or less?

____

3. Approximately what percentage of Wyoming's landscape is 2,000 meters in elevation or less?

____

4. Approximately what percentage of Colorado's landscape is 2,000 meters in elevation or less?

____

5. How high in feet is 2,000 meters?

____

6. Looking just at lynx sightings; are lynx found at higher elevations in Montana, Wyoming, or Colorado?

____

7. Would the plant ***cover type*** (type of plants found at that location) be the same at 2,500 meters elevation in each state? Why or why not?

____

____

____

____

____

____

____

8. What forest type is probably represented at the elevations where lynx sightings occur in each state?

____

Notes

Lesson 4

Educator's Overview

Built-in Snowshoes

Summary

Students measure snow tracks of various wildlife species and calculate foot loading—they divide the weight of the animal by the total surface area of its feet. They use these calculations to discuss wildlife adaptations for moving in deep snow and discuss implications for interspecies competition and lynx management.

Duration

Two 45-minute class periods

Vocabulary

Adaptation

Boreal

Foot loading

Mesocarnivore

Subalpine forest

Learning Objectives

Students will be able to:

- Calculate the foot loading ratios of ten wildlife species in English or metric units.
- Describe how foot loading affects the amount of energy an animal must exert to move in snow.
- Infer the impact of low or high snow pack on lynx survival.

Background

The Canada Lynx is uniquely adapted to live in the extremely snowy environment of Colorado's high altitude coniferous forests. A lynx is about as big as a medium-sized dog. Its long legs, light body, and sizable feet reduce its foot loading, the ratio that could be called a "sink in the snow coefficient." This enables the lynx to move quickly and easily over deep snow that might be an obstacle to other predators.

Teaching Strategies

1. Thoroughly read the student activity for Built-in Snowshoes.

2. ***Optional:*** If you have a large, flat piece of Styrofoam, you can open this activity by setting up the following scenario for students: Ask them to imagine that the floor was tiled with this Styrofoam. *Would it be easier to walk across the floor in ladies spike heels or flat soled shoes? Why? Would that be true even if the persons wearing the shoes were the same height and weight?* Now ask them to imagine that the classroom floor was covered with four feet of snow and continue with the next step.

3. Begin by discussing the difficulty of moving in deep snow. Ask students:

Have you ever tried to walk in deep snow?

Have you ever tried to chase a friend while playing in deep snow?

Discuss how running—and even walking—in deep snow is very tiring and burns up a lot of energy (calories) in a short period of time.

Ask students to brainstorm how moving around in deep snow can be made easier. They may think of several possibilities, which may include:

- Having snowshoes or skis;
- Being lighter;
- Being taller and having longer legs.

Discuss why each of these would make it easier to move around in snow and ask students to give an example from personal experiences.

4. Explain that wild animals also have difficulty moving about in deep snow. They burn up a lot of calories, too. If animals burn more calories than they consume, they may not survive. Ask students to think about animals that have adaptations that make it easier to move through snow. Ask them to list examples of animals that employ some of the same strategies they listed for humans. These may include:

- Snowshoe hares have big feet that enable them to move on top of snow;
- Moose have long legs and can wade through fairly deep snow;
- Ptarmigan are light enough to move on top of snow.

5. Talk about using snowshoes again. Explain that using snowshoes reduces a person's foot loading. Foot loading ratios are an approximation of the pressure a walking animal places on snow, and as a result, the animal's sinking depth. The deeper an animal sinks, the more energy it must expend to move through the snow.

6. Explain that students will be examining and comparing foot loading ratios of various wildlife species. They will use this information to learn more about the ecology of the lynx and some implications for the lynx reintroduction program in Colorado. ***Optional:*** You may also want to place the pelts from the *Lynx Loan Box* out so students can examine the feet of the animals they will be comparing.

7. Hand out the student readings and materials. Ask students to read the background information and notify you when they are ready to begin calculating foot loading ratios.

8. Demonstrate how to trace a foot print. Trace a line around the pad of the foot, but do not include claws. Look at these examples for the red squirrel and the pine marten:

Red Squirrel

Pine Marten

Materials and Preparation

- *Student packet:* Built-in Snowshoes
- *Graph paper (**Optional:** photocopy acetate overlays of graph paper grid for easier tracing)*
- *Calculators*
- ***Optional:*** *Large, flat piece of Styrofoam, about the length and height of a floor tile, and about 1–2" thick; a ladies spike heeled shoe, and a flat soled shoe.*
- ***Optional props:*** *A pair of snowshoes and/or a pair of skis*
- ***Optional:*** *Obtain* Lynx Loan Box *from your local DOW Regional Office*

9. Check that students understand the example for estimating the area of a footprint. Make sure that students have properly calculated the scale of their graph paper, which may be different than the example shown.

10. To save time and to avoid frustrating the students, have each student calculate the foot loading for just one animal. Randomly assign a species to each student. Since there will probably be more than one student calculating the ratio for each species, they should be able to compare their answers. If students have wildly different answers for a species, they can work through the calculations again to find ratios they can agree on.

11. Compile the ratios in a visible place. Ask students to complete their Foot Loading tables before answering the questions.

12. Discuss answers to the questions.

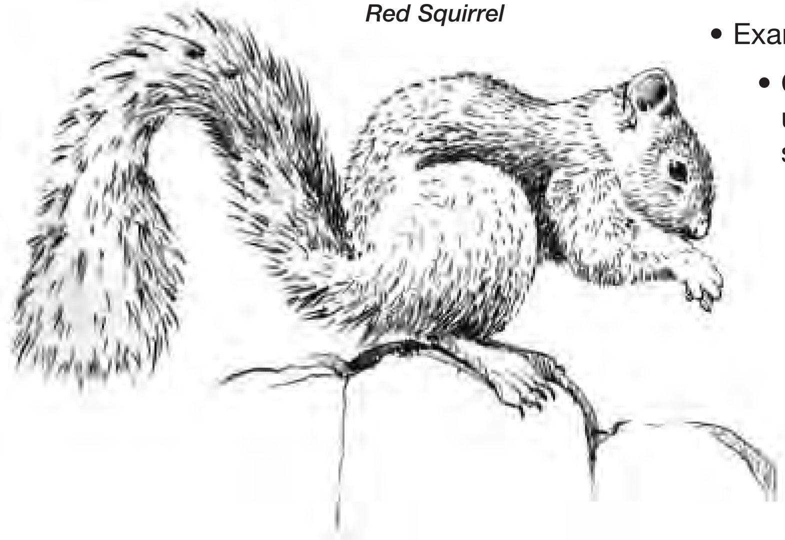
Assessment

Have students determine their own foot loading ratios with and without snowshoes or skis.

Extensions

- Investigate a Colorado Precipitation Map for areas of highest snowfall or investigate snow monitoring stations—SNOTEL sites (for SNOwpack TELemetry). The Natural Resources Conservation Service (NRCS) installs, operates, and maintains this extensive, automated system to collect snowpack and related climatic data in the Western United States. The system evolved from NRCS's Congressional mandate in the mid-1930's "to measure snowpack in the mountains of the West and forecast the water supply." SNOTEL sites can be located at this Web site: ***http://www.wcc.nrcs.usda.gov/factpub/sntlfct1.html***.
- Examine real tracks in snow.
  - Compare the sinking depth of an area of untrammeled snow to an area of packed snow (like a ski trail or snowmobile trail).

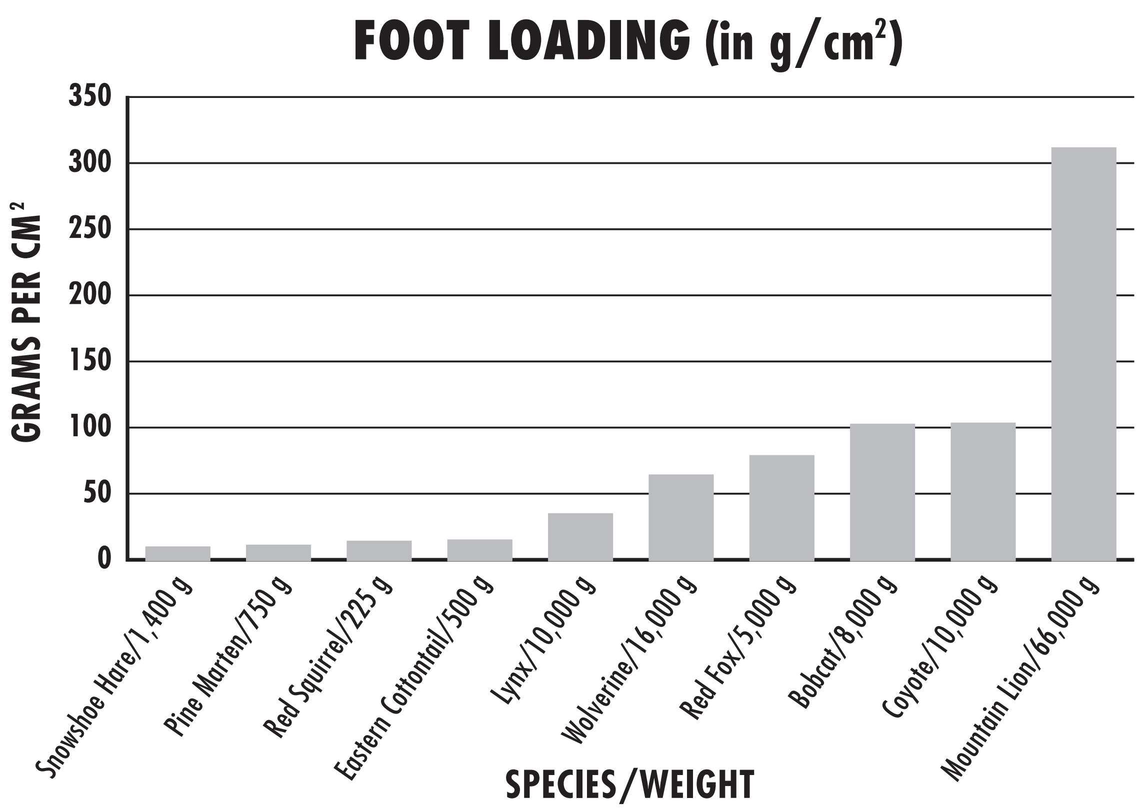
Red Squirrel



Pine Marten

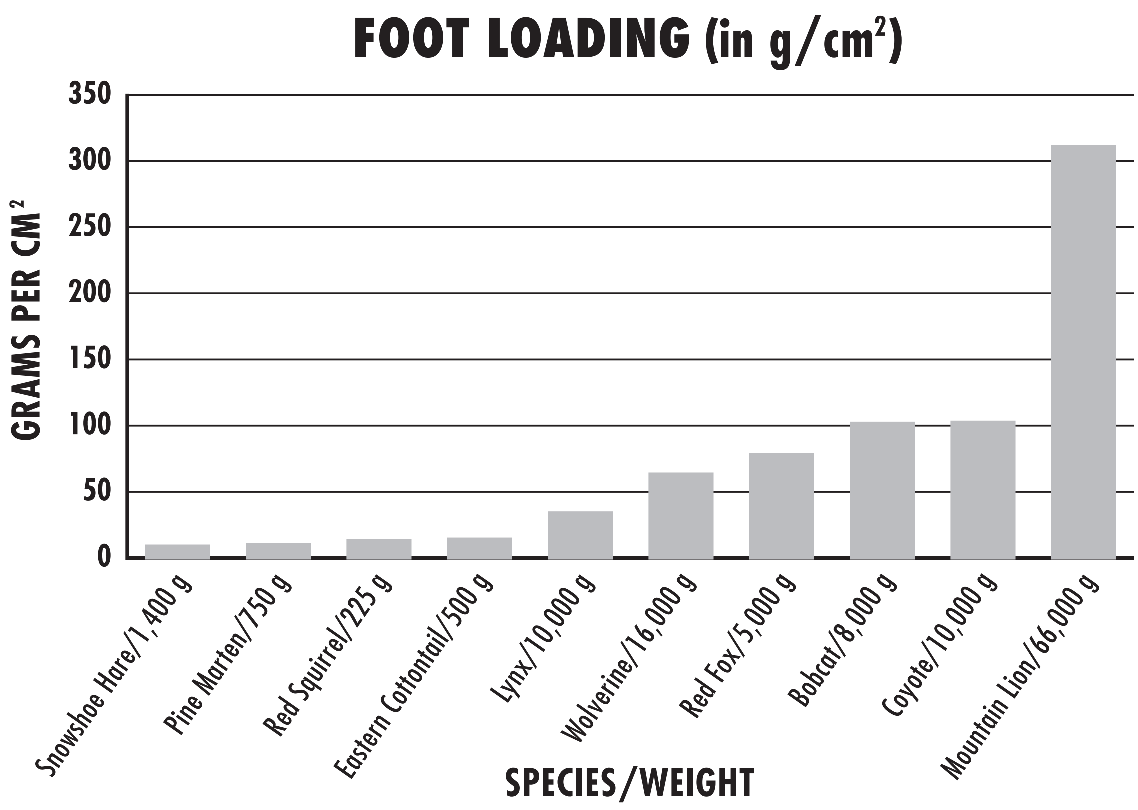
Student Activity Answer Keys

FOOT LOADING FOR VARIOUS WILDLIFE SPECIES (English Measurements)					
Wildlife Species	Weight (lbs)	Front Feet Surface Area (area of one foot in in^2) x 2	Hind Feet Surface Area (area of one foot in in^2) x 2	Total Surface Area of Feet (in^2)	Foot Loading lbs/in^2
Snowshoe Hare	3	1.80 x 2 = 3.6	12.8 x 2 = 24.16	27.76	0.11
Pine Marten	1.5	3.12 x 2 = 6.24	3.24 x 2 = 6.48	12.72	0.12
Red Squirrel	0.5	0.56 x 2 = 1.12	0.88 x 2 = 1.76	2.88	0.17
Eastern Cottontail	1	0.80 x 2 = 1.60	2.16 x 2 = 4.32	5.92	0.17
Lynx	22	11.92 x 2 = 23.84	11.64 x 2 = 23.28	47.12	0.47
Wolverine	35	9.52 x 2 = 19.04	10.4 x 2 = 20.8	39.84	0.88
Red Fox	10.5	2.72 x 2 = 5.44	2.32 x 2 = 4.64	10.08	1.04
Bobcat	17	3.12 x 2 = 6.24	3.04 x 2 = 6.08	12.32	1.38
Coyote	23	4.36 x 2 = 8.72	3.28 x 2 = 6.56	15.28	1.51
Mountain Lion	145	9.72 x 2 = 19.44	6.80 x 2 = 13.6	33.04	4.39



Student Activity Answer Keys (cont.)

FOOT LOADING FOR VARIOUS WILDLIFE SPECIES (Metric Measurements)					
Wildlife Species	Weight (in grams)	Front Feet Surface Area (area of one foot in cm^2) x 2	Hind Feet Surface Area (area of one foot in cm^2) x 2	Total Surface Area of Feet (cm^2)	Foot Loading (g/cm^2)
Snowshoe Hare	1,400	11.61 x 2 = 23.22	77.94 x 2 = 155.88	179.1	7.82
Pine Marten	750	20.13 x 2 = 40.26	20.90 x 2 = 41.8	82.06	9.14
Red Squirrel	225	3.61 x 2 = 7.22	5.68 x 2 = 11.36	18.58	12.11
Eastern Cottontail	500	5.16 x 2 = 10.32	13.94 x 2 = 27.88	38.2	13.09
Lynx	10,000	76.90 x 2 = 153.8	75.10 x 2 = 150.2	304	32.89
Wolverine	16,000	61.42 x 2 = 122.84	67.1 x 2 = 134.2	257.04	62.25
Red Fox	5,000	17.55 x 2 = 35.10	14.97 x 2 = 29.94	65.04	76.88
Bobcat	8,000	20.13 x 2 = 40.26	19.61 x 2 = 39.22	79.48	100.65
Coyote	10,000	28.13 x 2 = 56.26	21.16 x 2 = 42.32	98.58	101.44
Mountain Lion	66,000	62.71 x 2 = 125.42	43.87 x 2 = 87.74	213.16	309.63



1. What does 1.5 lbs/in^2 as a measure of foot loading actually mean? ***A foot loading ratio of 1.5 lbs/in^2 means that every square inch of the animal's sole supports 1.5 pounds of body weight. The higher the number, the more pounds of body weight each square inch supports—and the more the animal will sink into the snow.***

2. The bobcat and the lynx have nearly the same average body weight, yet the lynx has a much lower foot loading ratio. Why? How might that influence the use of Colorado habitats by these two cat species? ***The lynx has a much lower foot loading ratio because the surface area of its feet is so large (47.12 in^2). The surface area of the bobcats' feet is much smaller. During winter months the lynx would have a greater advantage in moving through the deep snow, while the bobcat would sink in deeper and expend more energy moving around and probably could not catch their prey. Rather than starve, bobcats typically live in drier habitats than lynx, at least during the winter months.***

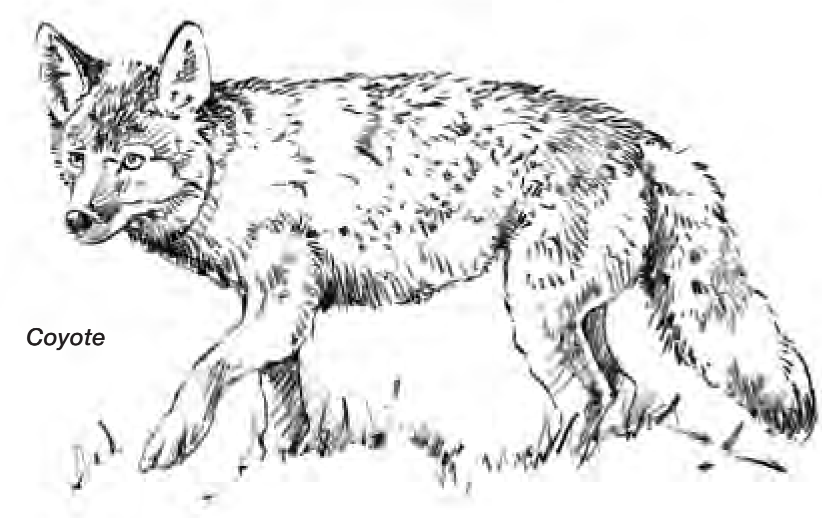
3. The eastern cottontail rabbit's foot loading ratio is not as low as the snowshoe hare, but it is lower than the lynx. Why doesn't the eastern cottontail rabbit live in the subalpine forest? ***Species have many requirements and many adaptations. The eastern cottontail does not have thick enough fur and also cannot find the food it eats in the subalpine forest.***

4. The red fox weighs half that of a lynx, yet, its foot loading ratio is more than two times greater than the lynx. Why? ***The red fox has very small feet, so despite its light weight, its foot loading is high.***

5. All of the predators listed would love to eat a snowshoe hare for a winter's meal, but only one likely will. Why? ***Most of the predators listed have such high foot loading ratios that they would likely expend too many calories moving through the deep snow to justify hunting a snowshoe hare. So, they avoid the very high mountain areas of Colorado in the winter. Only the lynx is uniquely adapted for this environment. The pine marten weighs quite a bit less than a snowshoe hare, so is more likely to prey on small rodents.***

6. Roads have expanded dramatically in the high mountains during the last few decades. Would roads help or harm the competitive advantage that the lynx have compared to other predators in these areas? Explain. ***Roads make these areas more accessible to other predators. The competitive advantage of the lynx is reduced.***

7. Would a long-term drought help or harm the competitive advantage that lynx have in the high forests? Explain. ***Drought reduces snow fall, so less snow means more predators have access to the forests. The competitive advantage of lynx is reduced.***



Coyote

Lesson 4

Student Pages

Built-in Snowshoes

Colorado's ***subalpine*** forests are found in very high-mountain environments with elevations over 9,000 feet. These forests contain most of the same tree species found in Canada's ***boreal*** forests. During the brief summer months, subalpine forests are pleasant places to be. Maybe you have enjoyed summer camping or hiking in these areas and viewing the various wildlife species that also frequent these forests in the summer. Perhaps you've seen elk grazing in a high meadow. Maybe your canine hiking partner has picked up the scent of a hare and tugged hard on the leash. Certainly, you've enjoyed the antics of campground chipmunks. There are predators nearby, though you may not have noticed them: owls, coyotes, fox, cougar, bobcat and maybe even lynx.

As winter approaches, these high mountain forests become a harsh environment with fierce, icy winds and heavy snowfall. Additional snow is blown down from the alpine and trapped by the narrow, densely packed trees, often forming snow depths of more than five feet. Most people and wild animals avoid these high mountain areas during the long winter months. Elk migrate down to lower valley bottoms, chipmunks hibernate, and many of the predators move to less extreme environments.

The lynx and its primary prey—the snowshoe hare—are among the few animals that are active, year-round residents of subalpine forests. Living here in winter—where it is extremely cold and snow cover is an obstacle to movement—requires some unique adaptations. ***Adaptations*** are anatomical, physiological, or behavioral changes that improve a population's ability to survive.

Lynx, like other animals that stay in subalpine forests year-round, have special adaptations to move through or over snow. Like coyotes, bobcats, and foxes, lynx are ***mesocarnivores***—mid-sized carnivores. They aren't as heavy as larger carnivores like mountain lions or bears and will not sink into deep snow as easily. Lynx also have unusually long legs compared to other members of the cat family. These long legs are an advantage in the deep snow. But the most distinctive adaptation is the lynx's unusually large feet. This activity focuses on the body weight to foot-surface ratio, called ***foot loading***, of the lynx and several other mammals found in Colorado's high mountains. The foot loading ratio is an approximation of the pressure a walking animal places on snow, and as a result, the animal's sinking depth. The deeper an animal sinks, the more energy it must expend to move through the snow. If an animal expends too much energy—the calories it gets from food—it may starve.

Mountain Lion

Determine the Foot Loadings of Some Colorado Wildlife.

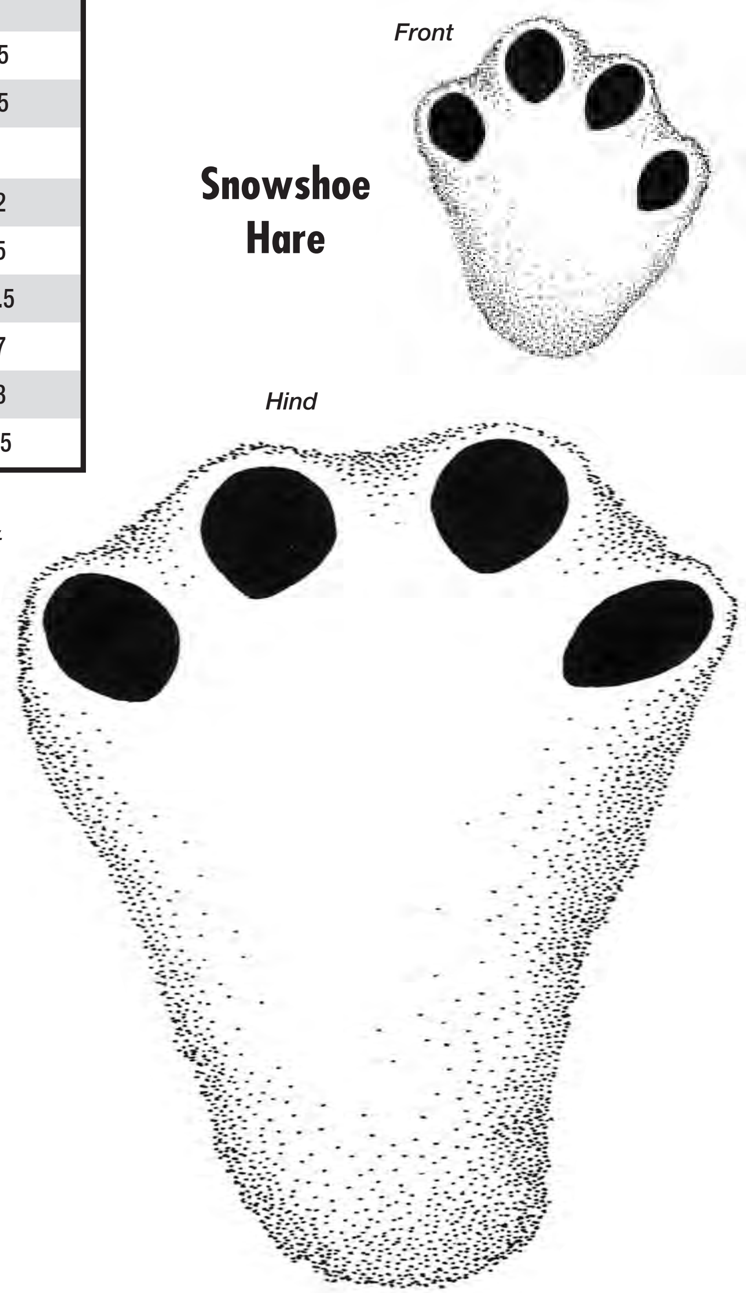
A. These are the body weights of ten mammals commonly found in Colorado's subalpine forests.

Wildlife Species	Body Weight (grams)	Body Weight (pounds)
Snowshoe Hare	1,400	3
Pine Marten	750	1.5
Red Squirrel	225	0.5
Eastern Cottontail	500	1
Lynx	10,000	22
Wolverine	16,000	35
Red Fox	5,000	10.5
Bobcat	8,000	17
Coyote	10,000	23
Mountain Lion	66,000	145

Body weights are average weights listed in Scats and Tracks of the Rocky Mountains*, by James C. Halfpenny. ©1998 by Falcon Publishing, Inc., Helena, Montana.*

B. The following pages contain the snow tracks, to scale, of each of these species. Track illustrations are based on minimum outline measurements listed in *Scats and Tracks of the Rocky Mountains*, by James C. Halfpenny. ©1998 by Falcon Publishing, Inc., Helena, Montana.

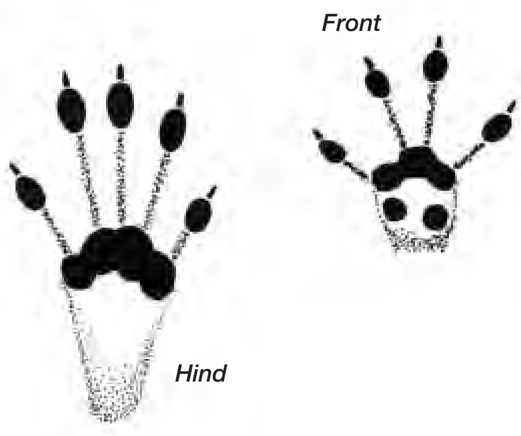
Snowshoe Hare



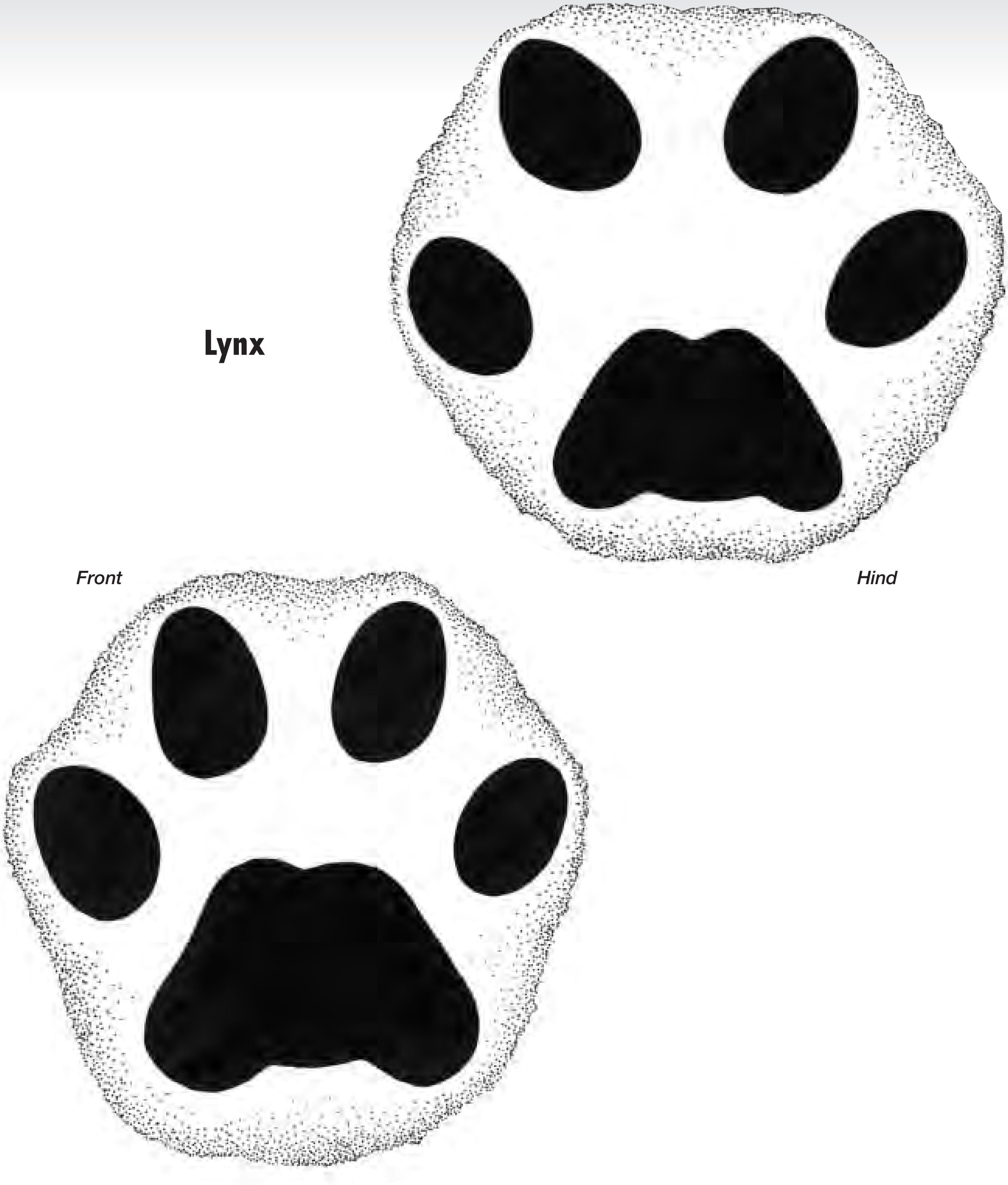
Pine Marten

Eastern Cottontail

Red Squirrel

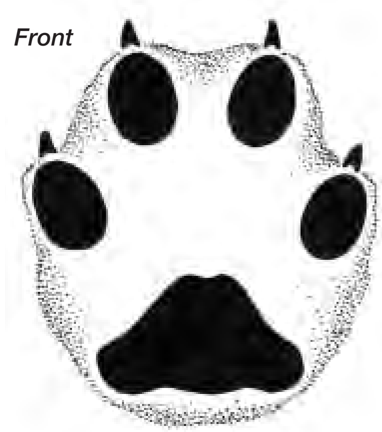


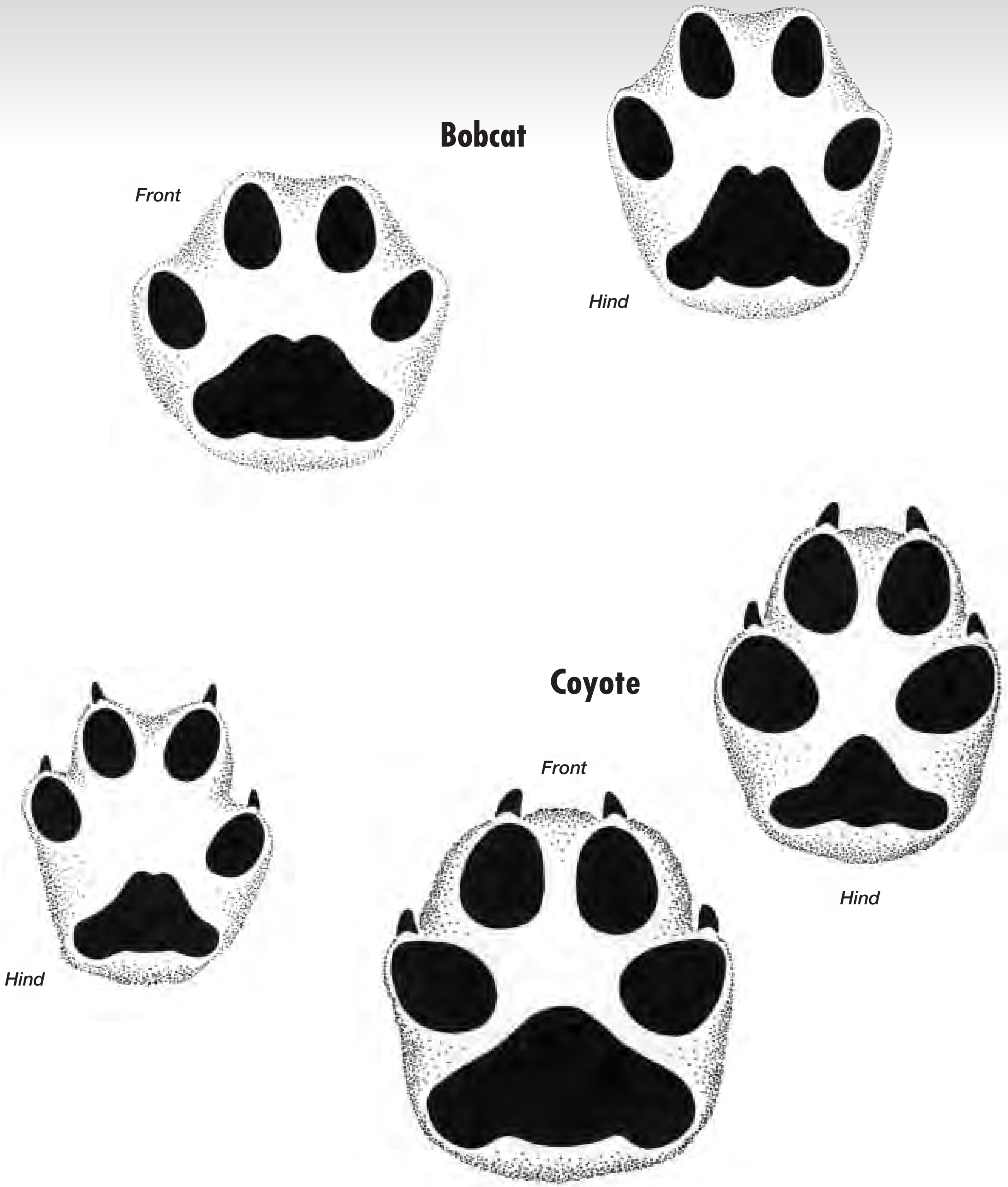
Lynx



Wolverine

Red Fox




Bobcat
Front
Hind
Coyote
Front
Hind
Hind

Mountain Lion

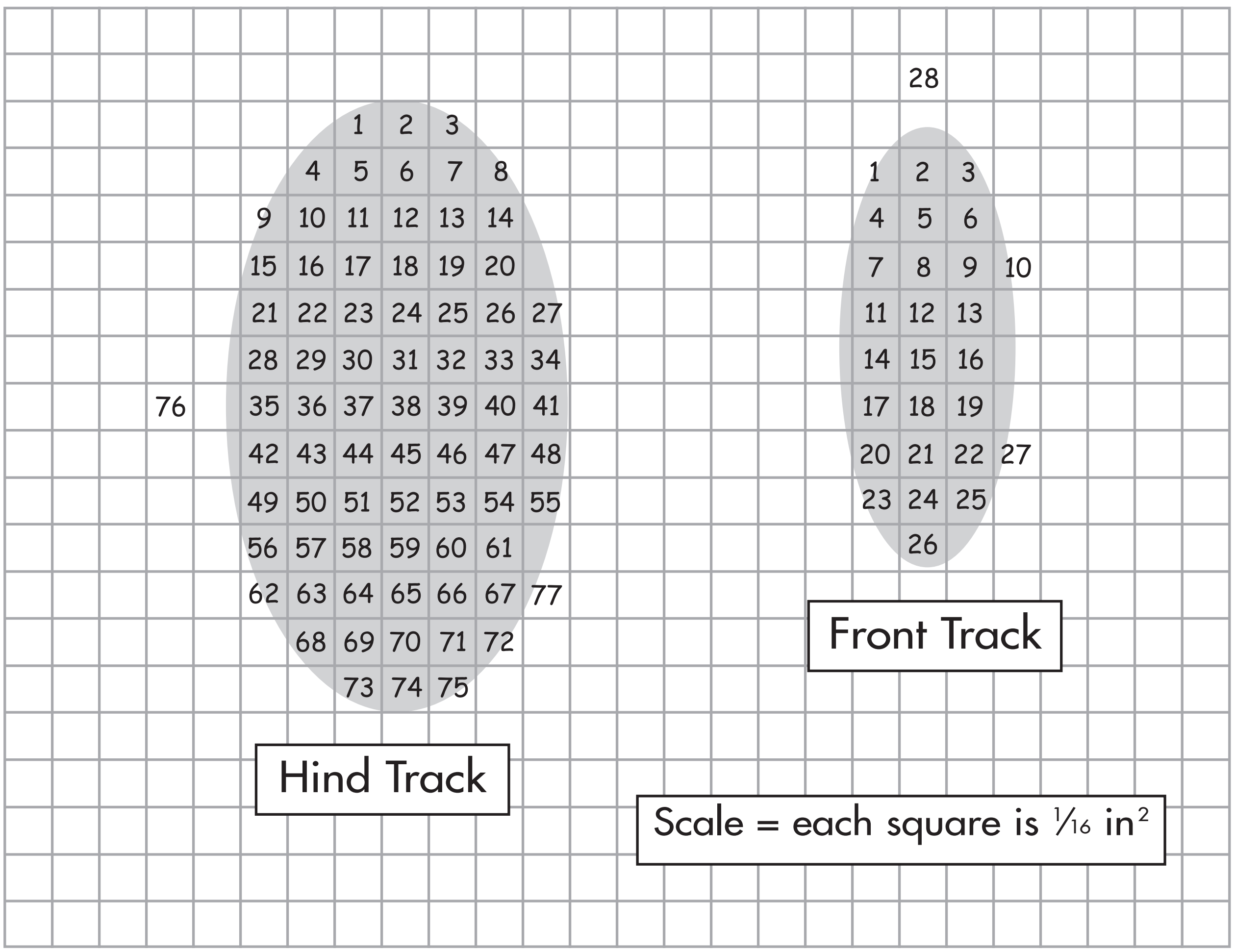
Front

Hind

C. Use the snow track illustrations provided to determine the surface area of each species' feet.

1. Get a piece of graph paper. Check the scale of the graph paper by measuring how many squares are found in one square inch or one square centimeter. In our example, there are 16 squares found in 1 square inch, so our scale is 1 square $= \frac{1}{16}$ $in^2 = 0.06$ in^2.
2. Lay the graph paper over the track illustrations provided. Trace the track (do not include the claws) and count the number of squares (estimate partial squares) to determine the surface area. Be sure to do this for the front foot and hind foot.

3. Multiply the measurement of the front foot by two, to determine the total surface area for both front feet. Then multiply the measurement of the hind foot by two. Add the total for the front feet and the hind feet together to get the total surface area of all four feet. Here is an example of how to do this:



Hind Track is approximately 77 squares (author's estimate), so 77 squares x 0.06 squares per inch = 4.62 in^2

Front Track is approximately 28 squares (author's estimate), so 28 squares x 0.06 squares per inch = 1.68 in^2

Total surface area of tracks =
4.62 in^2 x 2 = 9.24 in^2
1.68 in^2 x 2 = 3.36 in^2
12.60 in^2

D. To determine the foot loading ratio for each species, divide the average weight by the surface area of all four feet. For our example, we'll pretend our animal weighs 20 lbs. You can do the same calculations using metric units (grams of weight or mass, and centimeters of surface area).

So, for our example:

20 lbs/12.6 inch^2 = 1.59 lbs/inch^2

E. Complete this chart.

FOOT LOADING FOR VARIOUS WILDLIFE SPECIES					
Wildlife Species	**Weight (in g or lbs)**	**Front Feet Surface Area (measurement of one foot in cm^2 or in^2) x 2**	**Hind Feet Surface Area (measurement of one foot in cm^2 or in^2) x 2**	**Total Surface Area of Feet (in cm^2 or in^2)**	**Foot Loading in g/cm^2 or lbs/in^2**
Snowshoe Hare					
Pine Marten					
Red Squirrel					
Eastern Cottontail					
Lynx					
Wolverine					
Red Fox					
Bobcat					
Coyote					
Mountain Lion					

F. Construct a bar graph arranging the foot loading ratios from least to greatest.

G. Discuss your results.

1. *What does 1.5 lbs/in^2 as a measure of foot loading actually mean?*

2. The bobcat and the lynx have nearly the same average body weight, yet the lynx has a much lower foot loading ratio. *Why? How might that influence the use of Colorado habitats by these two cat species?*

3. The eastern cottontail rabbit's foot loading ratio is not as low as that of the snowshoe hare, but it is lower than the lynx. *Why doesn't the eastern cottontail rabbit live in the subalpine forest?*

4. The red fox weighs half that of a lynx, yet, its foot loading ratio is more than two times greater than the lynx. *Why?*

5. All of the predators listed would love to eat a snowshoe hare for a winter's meal, but only one likely will. *Why?*

6. Roads have expanded dramatically in the high mountains during the last few decades. Would roads help or harm the competitive advantage that the lynx have compared to other predators in these areas? Explain.

7. Would a long-term drought help or harm the competitive advantage that lynx have in the high forests? Explain.

Wolverine

Lesson 5

Duration

Two 45-minute class periods

Vocabulary

Biotic potential
Browse
Carnivore
Carrying capacity
Control group
Controlled experiment
Density
Dependent variable
Distribution
Emigrate
Experimental group
Forbs
Generalist
Harvest
Herbivore
Hypothesis
Immigrate
Independent variable
Leveret
Limiting factor
Model
Observation
Pelt
Population
Population dynamics
Population model
Predator
Prey
Size
Specialist
Synchronous
Terrestrial

Educator's Overview

Hare Today, Gone Tomorrow

Summary

Student "research teams" evaluate snowshoe hare population cycle data and propose further investigations to understand these cycles.

Learning Objectives

After completing this activity, students will be able to:

- Write a testable scientific question based on a given scenario.
- Write a hypothesis that may explain population phenomena.
- Communicate scientific observations verbally, graphically, and in writing.
- Examine scientific data to describe and predict the interactions of populations and ecosystems.
- Design and defend a written plan for a scientific investigation.

Background

Scientific inquiry can be thought of as organized curiosity about the physical world. Curious people ask questions about what they see but do not understand. The search for answers to these questions through experiments or research leads to new information and often, new questions.

Scientific questions are open-ended and cannot be answered with a simple "yes or no." Broad questions such as *"Why do snowshoe hare and lynx populations cycle?"* are divided into more specific testable questions that can be answered through research or experimentation. *"Do snowshoe hare populations crash due to lack of food resources?"*

This activity gives students data and observations about lynx and snowshoe hare ecology and population dynamics. After evaluating the data or observations, student groups decide how best to communicate that information to their peers. Groups then generate questions for research that would explain the phenomena. Lastly, groups will propose a hypothesis and an experimental design that could be used to answer one of the research questions.

Teaching Strategies

1. Thoroughly read the student activity for *Hare Today, Gone Tomorrow*.

2. Ask students to complete the reading *Hare Today, Gone Tomorrow*.

3. Introduce or review the scientific process. If useful, give students a copy of *Stages of Scientific Research*. Explain that research is cyclical in nature, and that new information often leads to new questions. The new questions lead to new hypotheses and new investigations.

4. Discuss the reading and point out the stages of the scientific process. First, many observations were made about snowshoe hares. These observations were collected over time. People asked questions about these observations. Scientists made predictions about the relationships between snowshoe hares and lynx. They noticed that further observations did not support their simple predator/prey model.

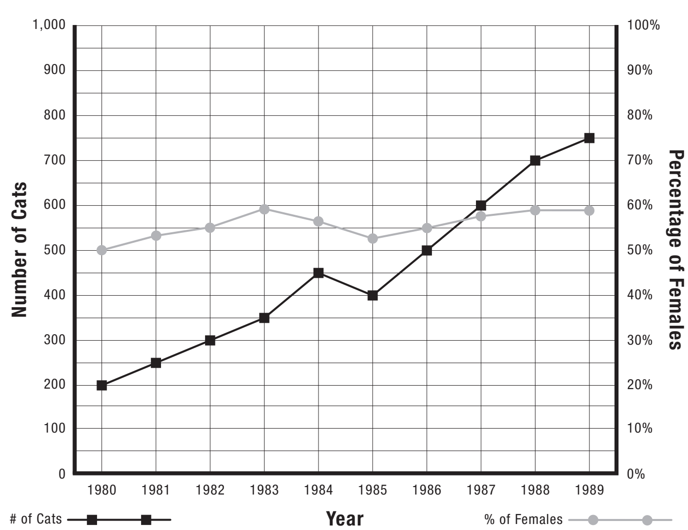
5. Discuss the graph showing the snowshoe hare and lynx pelt data over time. Over 90 years of data are displayed in this graph. Ask students to imagine what it would be like to make sense of all the numbers if they were only shown in a large data table! Graphs quickly show concepts that would need very lengthy written descriptions.

6. Explain that graphs take many forms. Students may be familiar with many types of graphs, but most often, scientists use line graphs and bar graphs. Explain to students that each of these graphs is used in a particular situation:

Bar graphs are designed to make comparisons of data. This data represented in bar graphs are not necessarily dependent on any other variables. For example, bar graphs can be used to compare the populations of different countries or the number of people who buy certain types of cars.

Line graphs show trends, such as how things change over time. They are the best type of graphs to use to show how one factor affects another factor. They are typically ***used to express the relationship between independent and dependent variables.*** For example, a line graph would be used to show a baby's increase in length (dependent variable) over time (independent variable).

Sometimes on line graphs, scientists show results that use different scales of measurement, and need to use both y-axes to demonstrate these results. For example, if scientists were measuring both the population (in #'s) of cats in a city and the percentage of those cats that were female over a ten year period, the graph might look like:



Materials and Preparation

- *Student Pages:* Hare Today, Gone Tomorrow*, one photocopy per student*
- *Student Page:* What are the Lynx-Hare Population Dynamics?*, one photocopy per student*
- Research Team "X"—Observations *sheet, one photocopy per group of students or one for each student in the group*
- ***Optional:*** *Make an acetate transparency of the page:* Stages of Scientific Research *or provide photocopies for students*
- ***Optional:*** *Butcher paper or acetate transparencies and markers*

7. Explain the characteristics of an effective scientific question.

8. Explain to students that they will be getting some additional observations or data about lynx or snowshoe hare ecology. Then divide the students into six research teams.

9. Give each group of students a *What are the Lynx-Hare Population Dynamics?* and a *Research Team "X"—Observations* sheet.

10. The first task of each student research team is to interpret, based on what they have already learned, what these data/observations mean. They will need to decide what original question prompted the collection of this data. They will then decide how to present this information to their peers (verbally, graphically, written) and prepare a presentation.

11. The second task for student research teams is to determine what further questions the information might pose to scientists. The student research team should list these questions, and then choose one that seems most interesting to them. The team should pose a hypothesis and then design a ***controlled investigation*** that could support or disprove their predictions. They will present this plan to their peers for critique.

12. ***Optional:*** You may want to give students butcher paper or blank acetate sheets to prepare for their presentations.

13. Give student teams enough time to prepare their presentations (one class period).

14. Ask student groups to share their knowledge with the other research teams. Each team in the audience should be encouraged (respectfully!) to make suggestions to the presenting research team.

Assessment

Student completion of the activity demonstrates the ability to ask good questions, pose an explanation (hypothesis) for observed phenomena and design an experiment to test a hypothesis.

Extensions

- Include discussions of other population concepts: exponential growth, S-curves, J-curves, growth rates, density-dependent factors, and density-independent factors.
- Students search the internet for current phase (incline or decline) of snowshoe hare/lynx cycles in Canada and Alaska.
- Students examine whether lynx populations are synchronous worldwide.
- Students could research other species which exhibit cyclic population dynamics.

Student Activity Answer Key

Each research team has been given different information and data. All teams were presented this same set of questions:

1. ***What might be the original question that led scientists to collect this data?***

2. ***What does it mean?***

3. ***What is the best way to present this information to the other Research Teams?***

4. ***What new questions can be asked about this data?***

Choose one of these questions. Propose a hypothesis, and design an experiment that would prove or disprove your hypothesis.

This is an open-ended inquiry activity, and, in general, there is great latitude for response. For the first two questions, the responses should be similar to these:

Research Team A

1. What might be the original question that led scientists to collect this data? ***Does lack of food or poor quality food cause the snowshoe hare population to crash?***

2. What does it mean? ***While there may be more hares with supplemental food or higher quality food, the snowshoe hare population still cycles.***

Research Team B

1. What might be the original question that led scientists to collect this data? ***Do snowshoe hare populations cycle everywhere? Do snowshoe hare populations cycle at the same time everywhere?***

2. What does it mean? ***Snowshoe hare cycles tend to occur in near synchrony across much of the boreal forests of Canada.***

Research Team C

1. What might be the original question that led scientists to collect this data? ***Does snowshoe hare population density influence hare reproduction?***

2. What does it mean? ***Reproduction rates decrease when there is a greater density of snowshoe hares.***

Research Team D

1. What might be the original question that led scientists to collect this data? ***How is the survival rate of snowshoe hares influenced by population density?***

2. What does it mean? ***Adult survival decreases when population density is high.***

Research Team E

1. What might be the original question that led scientists to collect this data? ***Would excluding predators keep the snowshoe hare population from cycling? Would excluding predators and providing supplemental food keep the snowshoe hare population from cycling?***

2. What does it mean? ***The snowshoe hare populations still cycled even when predators were excluded. The areas that had also been given supplemental food had more hares, but even those hare populations cycled.***

Research Team F

1. What might be the original question that led scientists to collect this data? ***Are snowshoe hare cycles in Montana the same as those just to the north in Canada?***

2. What does it mean? ***The peaks and valleys of the cycles appear to be nearly synchronous.***

What to Look for in Student Presentations

For their presentation, each research team should be able to construct a properly labeled graph of their data. Each graph should have a title. The X-axis and Y-axis (or both y-axes) should describe the type of data presented and the units of measurement. Research teams should also be able to demonstrate that they understand the information in a verbal presentation to their peers.

Each research team should be able to explain how their "new" questions relate to the information they have collected. The team should be able to choose one of these questions and describe the logic or thought process behind the investigation that they have designed to answer the question.

Snowshoe Hare

Stages of Scientific Research

Collecting Observations

Asking Effective Questions

- Open-ended—Cannot be answered with a simple yes or no.
- Testable—A scientist can attempt to answer the question through research or experimentation.

Forming Hypotheses and Making Predictions

- Hypotheses are explanations that might be true—they are statements that can be tested by additional observation or experimentation.
- Predictions are the expected outcome of a test, assuming the hypothesis is correct.

Gathering Data

- Scientific investigations are controlled experiments.
- An experimental group (a group that receives some type of experimental treatment) is compared to a control group (which does not receive any treatment).
- The experimental group and the control group are identical except for one factor or variable, the independent variable.
- What is measured (the results) is the dependent variable.

Drawing Conclusions

Notes

Lesson 5

Student Pages

Hare Today, Gone Tomorrow

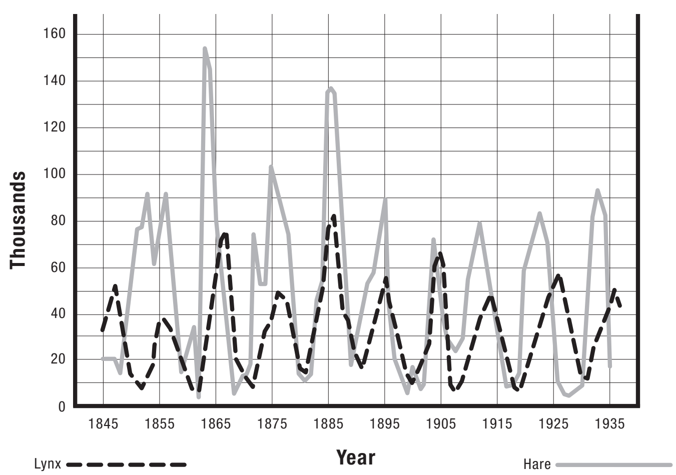
In 1831, the manager of a Hudson's Bay Company post in northern Ontario, Canada, wrote to the head office in London. Profits would be down, he reported, because the local Ojibway Indians were starving due to a scarcity of "rabbits." The "rabbits" were actually snowshoe hares. The Ojibway were unable to trap animals for fur for the company because they spent all their time fishing and trying to survive.

The Ojibway were not the only ones starving. Every ***carnivore*** (meat eater) in the boreal forest eats snowshoe hare—including hawks, owls, eagles, coyotes, foxes, wolves, fishers, martens, minks, wolverines and lynx. Most of these animals are ***generalist predators***—they eat a wide variety of ***prey***. When hares are scarce, they quickly switch to other sources of food, such as fish, squirrels, or mice. Lynx, however, are ***specialist predators*** that feed almost exclusively on snowshoe hares.

Snowshoe hare scarcity was reported regularly in 18th and 19th century Canadian historical documents. At other times, reports said snowshoe hares were so plentiful that "one could hear continuous munching and crunching of the rabbits eating any vegetation in site." Wildlife biologists began to examine these hare peaks and die-offs in the early 1900's, using the fur trading records of Hudson's Bay Company.

Lynx-Hare Population Cycles

Since its beginning in 1671, Hudson's Bay Company kept meticulous data of every ***pelt*** (preserved animal skin/fur) of every species collected at each of their trading posts in Canada. When snowshoe hare pelt numbers were plotted on a graph, it appeared that there was a population die-off approximately every ten years. A very interesting pattern seemed to emerge when the lynx pelt numbers were added to the graph. The rise and fall in lynx numbers mirrored, with a slight time lag, the rise and fall of snowshoe hare populations.



(Adapted from Odum, Fundamentals of Ecology, Saunders, 1953)

Was there a direct cause and effect relationship? Did other predator populations rise and fall with the snowshoe hare cycles?

Population Dynamics

A ***population*** consists of all the individuals of a species that live in a particular place at a particular time. Populations are constantly changing in response to environmental conditions. They change in ***size*** (number of individuals), ***density*** (number of individuals in a certain area), and ***distribution*** (how individuals are arranged in an area). These changes are called ***population dynamics***.

A population grows when more individuals are born or move into the population (***immigrate***) than die or move out (***emigrate***) in a given period. Different species populations grow at different rates—they have different ***biotic potential***. For example, animals like the snowshoe hare start reproducing early in life, have large litters and can have as many as four litters each year. The lynx, on the other hand, has only one litter of one to three kittens each year. Therefore, hares have greater biotic potential than lynx.

As a population grows, resources that the population needs may become depleted. When this happens, the population stops growing or declines. Anything that limits the growth of the population is a ***limiting factor***. All of the limiting factors acting on a species determine its ***carrying capacity***, the number of individuals of a species that a given environment can support. Carrying capacity is not a fixed quantity and is affected by many things—competition between and within species, catastrophic events, fluctuations in food supply and other resources, climate changes and other factors.

Modeling Population Dynamics

When scientists try to predict how a population will change, they make a ***population model***. Models attempt to imitate the key characteristics of a real population. The spectacular lynx/snowshoe hare cycles seemed to predict the population dynamics of two closely tied predator and prey species. The lynx/hare graph is highlighted in most biology and ecology textbooks as one of the few examples of a simple predator/prey model.

There are two ***hypotheses*** (explanations) that could be supported by this simple model. The first is the *top-down control* hypothesis. According to this hypothesis, the predator populations control the prey populations. Lynx eat snowshoe hares and the lynx population continues to grow. Gradually, there are so many lynx eating hares that the hare population crashes. Then, lacking food, the lynx starve. This allows the snowshoe hare population to increase again, and the cycle starts over.

In the *bottom-up control* hypothesis, the prey population controls the predator population. The hare population continues to increase as long as there is plenty of vegetation. There is more food for lynx, so the lynx population increases. Finally, the snowshoe hares are so numerous that they eat themselves out of house and home (the vegetation is gone) and they begin to starve. In turn, the lynx have nothing to eat, and they starve. The vegetation begins to recover, and the cycle starts over.

Life is Never Simple

Things are never as simple in nature as they first appear. First, someone noticed that snowshoe hare populations continued to cycle even on an island where there were no lynx. Then, another person noticed that there was an area where snowshoe hare populations didn't have dramatic booms and busts, even though there were lots of predators. Yet another researcher noticed ***synchronous*** changes in hare populations that were far apart. The hare populations fluctuated *at the same time in the same manner*. *What was really behind all these cycles? How could scientists find out?*

What are the Lynx-Hare Population Dynamics?

It can be pretty difficult to sort out what is really happening in any population at any time. The natural starting place is collecting all the ***observations*** that have been made about the species and its environment. Observations, particularly ones that contradict each other, lead to questions. Scientists then try to form testable explanations that would answer the questions. A ***hypothesis*** is an explanation that might be true, and can be tested by additional observations or experimentation.

Compared to most scientists, wildlife biologists have it hard when it comes to designing experiments. It is really difficult to conduct a controlled experiment in an ecosystem. In a ***controlled experiment***, an ***experimental group*** (a group that receives some type of experimental treatment) is compared with a control group. The ***control group*** receives no experimental treatment. The control and experimental group are designed to be identical except for one factor or variable. The factor that is changed in an experiment is called the ***independent variable***. The variable that is measured (like the change in population) is called the ***dependent variable***.

As a member of the Lynx Reintroduction Team, you are trying to fathom the mystery of the lynx-hare population cycles and how they may affect your reintroduction plan. You will be given a collection of observations, and your task is to ask some questions and design an experiment to answer them.

Notes

Research Team A—Observations

Your research team gathered data and observations about snowshoe hare populations and their food. Your team discovered that the diet of snowshoe hares changes with the seasons. In the spring and early summer, hares eat nutrient-rich plants which are just emerging—grasses, horse-tails, and newly sprouted ***forbs*** (flowering plants) and shrubs. As the summer ends, the hares begin to feed mostly on woody ***browse***. Woody browse that is heavily grazed produces new shoots with high levels of toxins, which are less digestible. In winter, snowshoe hares feed primarily on tree bark. Trees can tolerate some bark gnawing, but when too many hares feed on the same tree, the tree retaliates and defends itself. The tree makes sap that covers the chewed area like a Band-Aid. The sap contains phenols and turpentine which are poisonous to hares.

Hares first excrete and then eat soft, green pellets of partly digested food. In much the same way as a cow chews and digests its food twice, these pellets go back into the hare's bag-like digestive chamber. In the chamber, additional nutrients are extracted before hard, fully digested pellets are eliminated.

During your team's literature search, you found this data table. *What might be the original question that led scientists to collect this data? What does it mean? What is the best way to present this information to the other Research Teams? What new questions can be asked about this data?* Choose one of these questions. Propose a hypothesis, and design an experiment that would prove or disprove your hypothesis.

DENSITY OF SNOWSHOE HARES ON THREE DIFFERENT STUDY PLOTS

	DENSITY OF SNOWSHOE HARES PER HECTARE		
Year	Control	Food	Fertilizer
1987	0.17	0.26	0.24
1988	0.53	1.03	0.61
1989	0.81	2.92	0.70
1990	1.58	3.49	2.11
1991	0.84	5.70	1.20
1992	0.30	1.56	0.24
1993	0.07	0.24	0.06
1994	0.06	0.25	0.55

Control—There was no manipulation of this study plot.
Food—Year-round supplemental food was provided for snowshoe hares on this study plot.
Fertilizer—This study plot was fertilized to increase plant growth.

From Krebs, C.J., S. Boutin, R. Boonstra, A.R.E. Sinclair, J.N.M. Smith, M.R.T. Dale, K. Martin, and R. Turkington. 1995. Impact of food and predation on the snowshoe hare cycle. *Science* 269: 1112–1115.

Research Team B—Observations

Your research team gathered lynx harvest data from three regions in Canada. Eastern Canada includes the large province of Quebec and extends to the Atlantic Ocean. The provinces of Saskatchewan, Manitoba, and Ontario form the region of central Canada. Western Canada includes the provinces of Alberta and British Columbia and borders the Pacific Ocean.

What might be the original question that led scientists to collect this data? What does it mean? What is the best way to present this information to the other Research Teams? What new questions can be asked about this data? Choose one of these questions. Propose a hypothesis, and design an experiment that would prove or disprove your hypothesis.

EASTERN CANADA

Year	Lynx
1955	1,200
1956	1,100
1957	1,200
1958	1,200
1959	2,500
1960	3,600
1961	3,400
1962	3,400
1963	3,800
1964	5,000
1965	4,000
1966	3,900
1967	2,500
1968	2,300
1969	2,400
1970	1,500
1971	1,600
1972	3,700
1973	6,200
1974	4,000
1975	2,600
1976	2,500
1977	2,700
1978	2,600
1979	2,600
1980	3,700
1981	3,800
1982	3,700
1983	1,500
1984	1,500
1985	1,200
1986	1,000
1987	900
1988	800
1989	800
1990	800
1991	700
1992	1,200
1993	1,000
1994	900

CENTRAL CANADA

Year	Lynx
1955	1,700
1956	1,700
1957	3,800
1958	8,000
1959	25,000
1960	19,000
1961	16,000
1962	16,000
1963	11,000
1964	3,700
1965	3,600
1966	3,600
1967	5,000
1968	11,000
1969	18,000
1970	17,500
1971	17,500
1972	1,760
1973	7,500
1974	3,700
1975	3,600
1976	5,500
1977	8,000
1978	10,500
1979	11,000
1980	8,500
1981	9,000
1982	6,000
1983	5,000
1984	1,000
1985	9,00
1986	1,000
1987	800
1988	900
1989	1,100
1990	1,200
1991	2,500
1992	2,000
1993	1,800
1994	1,800

WESTERN CANADA

Year	Lynx
1955	3,000
1956	3,000
1957	2,000
1958	2,500
1959	12,000
1960	15,000
1961	27,000
1962	24,000
1963	16,000
1964	12,000
1965	3,000
1966	2,500
1967	6,000
1968	4,000
1969	10,000
1970	17,500
1971	27,000
1972	27,000
1973	17,000
1974	8,000
1975	5,000
1976	4,000
1977	5,000
1978	10,000
1979	15,000
1980	15,000
1981	20,000
1982	14,000
1983	5,000
1984	2,500
1985	2,000
1986	2,000
1987	1,900
1988	2,000
1989	2,500
1990	1,800
1991	3,500
1992	2,400
1993	1,200
1994	1,100

From McKelvey, K.S., K.B. Aubrey, and Y.K. Ortega. 2000. History and distribution of lynx in the contiguous United States. Pages 207–264 in Ruggiero et al. eds. *Ecology and Conservation of Lynx in the United States*. Denver, CO: University Press of Colorado.

Research Team C—Observations

Snowshoe hares begin to breed in the spring when they are one year old. Each female can have three or four litters in a summer, with an average of five ***leverets*** (baby snowshoe hares) in a litter. Your team has gathered fifteen years of data about snowshoe hare density and reproduction in central Alberta, Canada.

What might be the original question that led scientists to collect this data? What does it mean? What is the best way to present this information to the other Research Teams? What new questions can be asked about this data? Choose one of these questions. Propose a hypothesis, and design an experiment that would prove or disprove your hypothesis.

DENSITY OF SNOWSHOE HARES/REPRODUCTION—CENTRAL ALBERTA, CANADA

Year	Number of Leverets/Female	Density (Number of Hares/Hectare)
1962	11	2.7
1963	8	1
1964	12	0.3
1965	16	0.2
1966	18	0.2
1967	16	0.3
1968	16	1
1969	15	1.5
1970	12	3.5
1971	9	5.1
1972	8	2.5
1973	7	0.8
1974	11	0.2
1975	14	0.05
1976	18	0.1

From Cary, J.R., and L.B. Keith. 1979. Reproductive change in the 10-year cycle of snowshoe hares. *Canadian Journal of Zoology* 57: 375–390.

Research Team D—Observations

Your team radio-collared adult snowshoe hares for several years to see what percent of them would survive for 30 days. The cause of death (mortality) for each hare varies.

What might be the original question that led scientists to collect this data? What does it mean? What is the best way to present this information to the other Research Teams? What new questions can be asked about this data? Choose one of these questions. Propose a hypothesis, and design an experiment that would prove or disprove your hypothesis.

DENSITY OF SNOWSHOE HARES/30-DAY SURVIVAL RATE

Year	Survival Rate Per 30 Days (%)	Density (Number of Hares/Hectare)
1977	92	0.1
1978	88	0.6
1979	86	1.0
1980	82	2.4
1981	72	2.5
1982	76	0.7
1983	75	0.2
1984	83	0.2
1985–1987	Too few hares captured to estimate survival accurately	1985 = 0.2; 1986 = 0.1; 1987 = 0.2
1988	90	0.5
1989	88	0.9
1990	84	1.5
1991	64	0.8
1992	77	0.3
1993	86	0.1
1994	86	0.1
1995	90	0.2

From Krebs, C.J., R. Boonstra, S. Boutin, and A.R.E. Sinclair. 2001. What drives the 10-year cycle of snowshoe hares? *BioScience* 51: 25–35.

Research Team E—Observations

Your research team has been studying snowshoe hare mortality. Your team has found that almost all snowshoe hares die of predation. The main predators of adult snowshoe hares are coyotes, lynx, goshawks, and great horned owls. Leverets are preyed upon by small raptors (boreal owls, Harlan's hawks, kestrels, and hawk owls) and small mammals (red squirrels, ground squirrels, weasels, and martens).

What might be the original question that led scientists to collect this data? What does it mean? What is the best way to present this information to the other Research Teams? What new questions can be asked about this data? Choose one of these questions. Propose a hypothesis, and design an experiment that would prove or disprove your hypothesis.

DENSITY OF SNOWSHOE HARES PER HECTARE

Year	Control	Predator Free	Predator Free and Food
1988	0.53	0.75	0.11
1989	0.81	0.69	3.22
1990	1.58	1.72	5.50
1991	0.84	1.53	4.94
1992	0.30	0.39	4.08
1993	0.07	0.17	1.42
1994	0.06	0.25	0.86

Control—There was no manipulation of this study plot.
Predator Free—Electric fences kept all terrestrial (land) predators out of this study plot.
Predator Free and Food—Electric fences kept all terrestrial (land) predators out of this study plot and supplemental food was provided for snowshoe hares.

From Krebs, C.J., S. Boutin, R. Boonstra, A.R.E. Sinclair, J.N.M. Smith, M.R.T. Dale, K. Martin, and R. Turkington. 1995. Impact of food and predation on the snowshoe hare cycle. *Science* 269: 1112–1115.

Snowshoe Hare

Research Team F—Observations

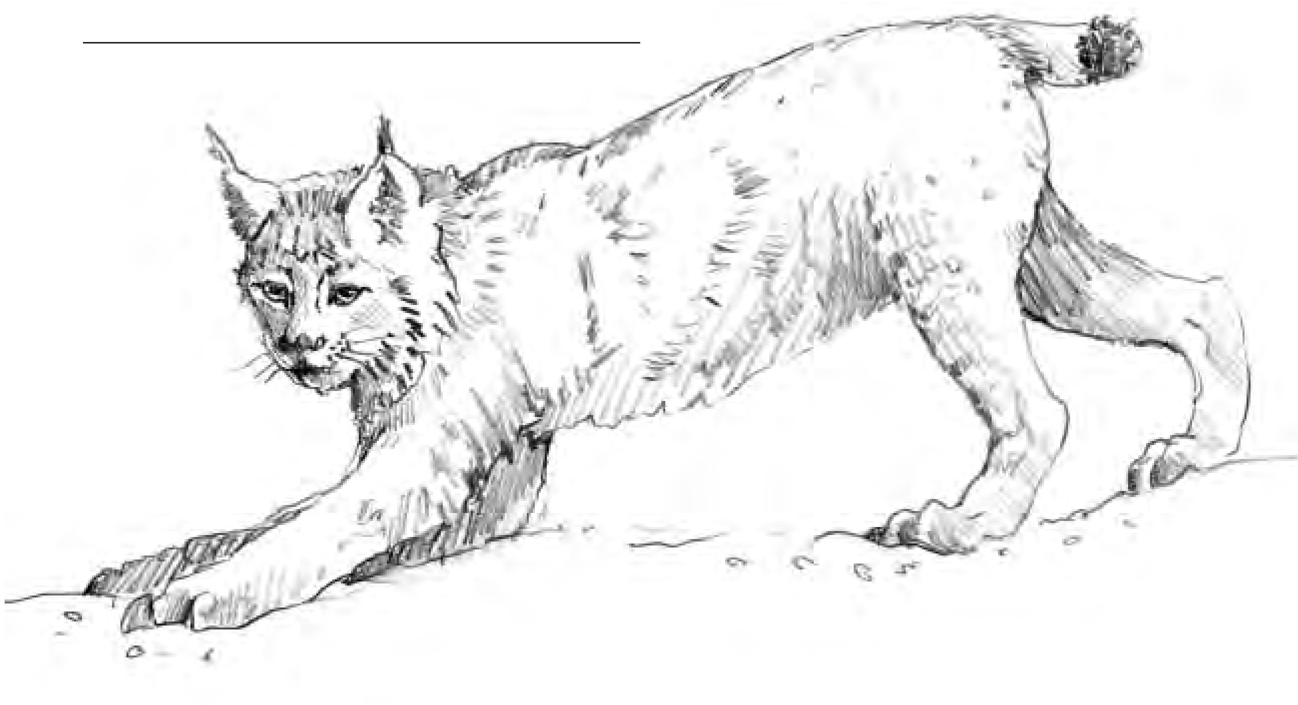
Your research team has compared lynx ***harvest data*** (number of animals taken by hunting or trapping) in Alberta and British Columbia, Canada with harvest data from Montana, USA. *What might be the original question that led scientists to collect this data? What does it mean? What is the best way to present this information to the other Research Teams? What new questions can be asked about this data?* Choose one of these questions. Propose a hypothesis, and design an experiment that would prove or disprove your hypothesis.

LYNX HARVEST COMPARISON

Year	Alberta and British Columbia	Montana
1950	3,000	5
1951	2,000	14
1952	6,000	10
1953	4,000	20
1954	6,000	18
1955	3,000	23
1956	3,000	40
1957	2,000	32
1958	2,500	28
1959	12,000	45
1960	15,000	40
1961	27,000	30
1962	24,000	75
1963	16,000	380
1964	12,000	150
1965	3,000	160
1966	2,500	100
1967	6,000	55
1968	4,000	45
1969	10,000	50
1970	17,500	45
1971	27,000	300
1972	27,000	260
1973	17,000	160
1974	8,,000	250
1975	5,000	35
1976	4,000	24
1977	5,000	23
1978	10,000	50
1979	15,000	30
1980	15,000	35
1981	20,000	50
1982	14,000	50
1983	5,000	135
1984	2,500	120
1985	2,000	100
1986	2,000	55
1987	1,900	40
1988	2,000	5
1989	2,500	2

From McKelvey, K.S., K.B. Aubrey, and Y.K. Ortega. 2000. History and distribution of lynx in the contiguous United States. Pages 207–264 in Ruggiero et al. eds. *Ecology and Conservation of Lynx in the United States*. Denver, CO: University Press of Colorado.

Notes



Lesson 6

Educator's Overview

No Cat Is An Island

Summary

Students use maps of the geographic distribution of lynx in North America as part of a simulation game that investigates ecological theories related to island biogeography.

Duration

One to two 45-minute class periods

Vocabulary

Biogeography

Biome

Boreal

Circumboreal

Circumpolar

Colonization

Dispersal

Indigenous

Island

Metapopulation

Peninsula

Recolonization

Recruitment

Source Population

Subpopulation

Succession

Taiga

Learning Objectives

Students will be able to:

- Describe the historic distribution of Canadian lynx in North America.
- Define and give examples of metapopulation species.
- Describe the pattern of dispersal and colonization common to metapopulation dynamics.
- Graph changes in populations and infer the probable future impact of a course of action—in this case, a reintroduction program.

Background

Biogeography is the science that studies the distribution of life, past and present. This activity looks at both the past and present distribution of Canadian lynx, and explores how a restoration program that mimics historic dispersal and colonization patterns may influence the species future presence in Colorado.

Teaching Strategies

1. Thoroughly read the student activity *No Cat Is An Island*.

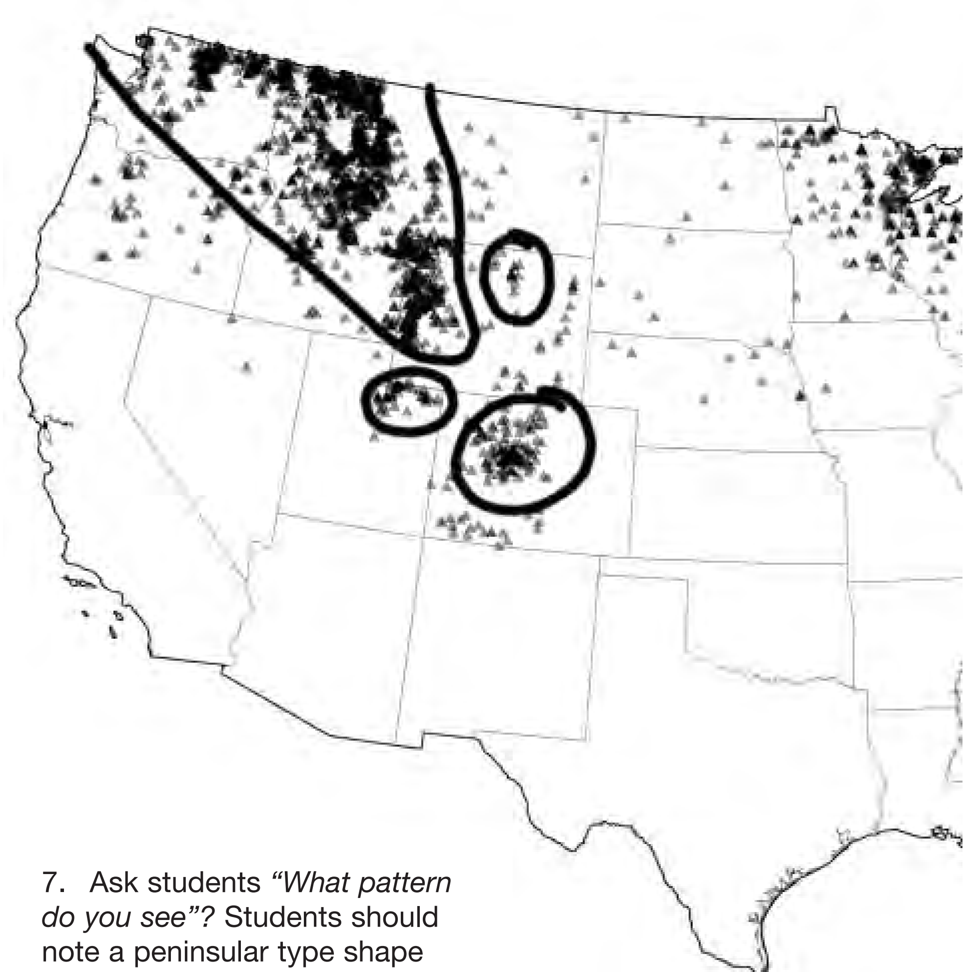
2. As a review of previous activities, ask students which habitat lynx prefer in Colorado. ***Lynx prefer subalpine forests***.

3. Hand out the student pages: *No Cat is an Island*. Allow the students some time to read the handout.

4. Divide the class up into the same student groups that completed Lesson 3, *Map That Cat* (preferably).

5. Return the maps that were completed in Lesson 3 to each group.

6. Show students the transparency: *Distribution of Lynx in the Conterminous United States*. Take a marker and loosely draw lines around the areas where there are high concentrations of lynx sightings (see diagram on the following page).



7. Ask students *"What pattern do you see"?* Students should note a peninsular type shape extending from Canada southward along the Rocky Mountains. They should also note that the peninsula shape begins to deteriorate at its southern-most periphery, creating more island-like features in Colorado, parts of Utah and Wyoming.

8. Review the student reading and connect it to this map.

9. Explain to students that if they think of northern Canada's boreal forests as the "mainland of lynx," then the Rocky Mountain chain may be thought of as a southern extension of that mainland; sort of like a peninsula. The "Rocky Mountain Peninsula's" high elevation allows it to have similar vegetation, climate, and lynx habitat to the boreal forests of Canada.

10. Ask students to imagine filling up the low elevations with a giant sea of water. Only the highest elevations would remain dry. The Rocky Mountain Peninsula would really be evident. But what would students then notice about the mountains of central Colorado and some parts of Utah and Wyoming? They become "islands" of lynx habitat, near to, but separate from the peninsula. Check that students understand the terms population, source population, subpopulation, and metapopulation.

Materials and Preparation

- *Maps completed in Lesson 3,* Map that Cat.
- *Acetate transparency:* Distribution of Lynx in the Conterminous United States
- *Student Pages:* No Cat Is An Island*, one photocopy per student.*
- *Student Pages:* The Metapopulation Game*, one photocopy per student.*
- *Student Pages:* The Metapopulation Game—Considering Other Impacts*, one photocopy per student*
- *Student Page:* Metapopulation Game Charts*, one photocopy per student*
- Lynx tokens—*photocopy one sheet per student. Send these token sheets home with students the night prior to the lesson to be cut apart—or—enlist a student aid to help cut these prior to the lesson. This will save classroom time.*
- *Coins (four per six-student group)*
- *Graph paper*

11. Now, give each student one copy of *The Metapopulation Game* and one copy of *The Metapopulation Game Chart*. Ask students, *"Can you think of some reasons why a lynx would deliberately leave its local habitat and travel in search of other habitat?* Some possibilities are that the lynx are hungry and looking for food; juveniles are leaving to find their own territory; or lynx are seeking mates.

12. Tell students they will be using their constructed maps for the metapopulation game, which will simulate the population cycles of lynx in these areas. They should follow the directions and answer the questions as they go along. They should feel free to ask for clarification of instructions if needed.

13. After students have completed the simulation game, review questions 10a through 10j.

14. Tell students that many changes in the United States due to human activity or other factors may have affected historical lynx dispersal and recolonization to the island habitats. Ask students to brainstorm what some of these activities might be. The list could include road construction, automobile traffic, development, logging, agricultural conflicts, recreation, and the like.

15. Discuss the results of the game and the implications for Colorado's lynx reintroduction program.

Assessment

- How well did students answer questions in either written or discussion format?
- How well did students graph lynx populations?

Extensions

- What other populations may follow some of the theories of metapopulations? (Spotted owl, wolverine, frogs, prairie dogs)
- What other species have healthy populations in mainland Canada and struggling metapopulations down the Rocky Mountain habitat peninsula? (Wolf, grizzly bear, wolverine) Should Colorado try to reintroduce those species?
- What is the status of the European Lynx? Do some of the theories of metapopulations apply there? Are there lynx reintroduction efforts in Europe?
- The ecology of island populations has long intrigued scientists. How did the Galapagos Islands influence the development Darwin's evolutionary theories?

Key

10. Your group should have played for a total of 30 years. Answer/discuss the following questions thoroughly:

a. Were any of the island populations extirpated? ***At least one island should go extinct; however, because this is based on random events—flipped coins—more than one island or no islands may have gone extinct. Distance from the peninsula is not a factor.***

b. Was that island extirpation due to deliberate actions or by random chance? ***Random chance.***

c. Did any of the island populations ever increase to over 10 lynx and maintain that number for more than 10 years? ***At least one island should have increased to over 10 lynx and maintained that number; however, because this is based on chance, sometimes more than one island or no islands may have experienced this.***

d. If so, was that island's successful population due to a sequence of deliberate actions or random chance? ***Random chance.***

e. Did you find that once an island's population reached 10 lynx that it was not likely to later become extinct? ***Generally that's true. Once an island population is large, it's much more likely to withstand losses due to random events. (This has important implications in Colorado's reintroduction program).***

f. Was the peninsula population extirpated? Why or why not? ***No. It had a larger population to begin with than the islands. Also, it is directly connected to Canada's source population.***

g. What was the effect of the lynx dispersal that occurred every 10 years? Did it help to successfully recolonize any of the islands? ***Lynx dispersal may help to recolonize the island. If an island is recolonized by a lynx, the lynx still has a 50/50 chance of survival on the very next coin flip.***

h. In real life, could island recolonization occur with one lynx? Also, in real life, would a dispersing lynx automatically travel to the island with the least number of lynx? ***No. A male and a female would be the necessary minimum. Pregnant females are not likely to disperse. Lynx would not be able to know which island had the least number of lynx.***

i. In real life, how do you think distance would affect the probability of successful dispersal and recolonization of an island habitat? Can you relate that to Colorado's position on the map as related to the peninsula? ***The farther the island is from the peninsula, the less likely a successful recolonization will occur. The odds of a dispersing lynx finding and recolonizing an island decreases with distance. Colorado is the farthest island from the peninsula.***

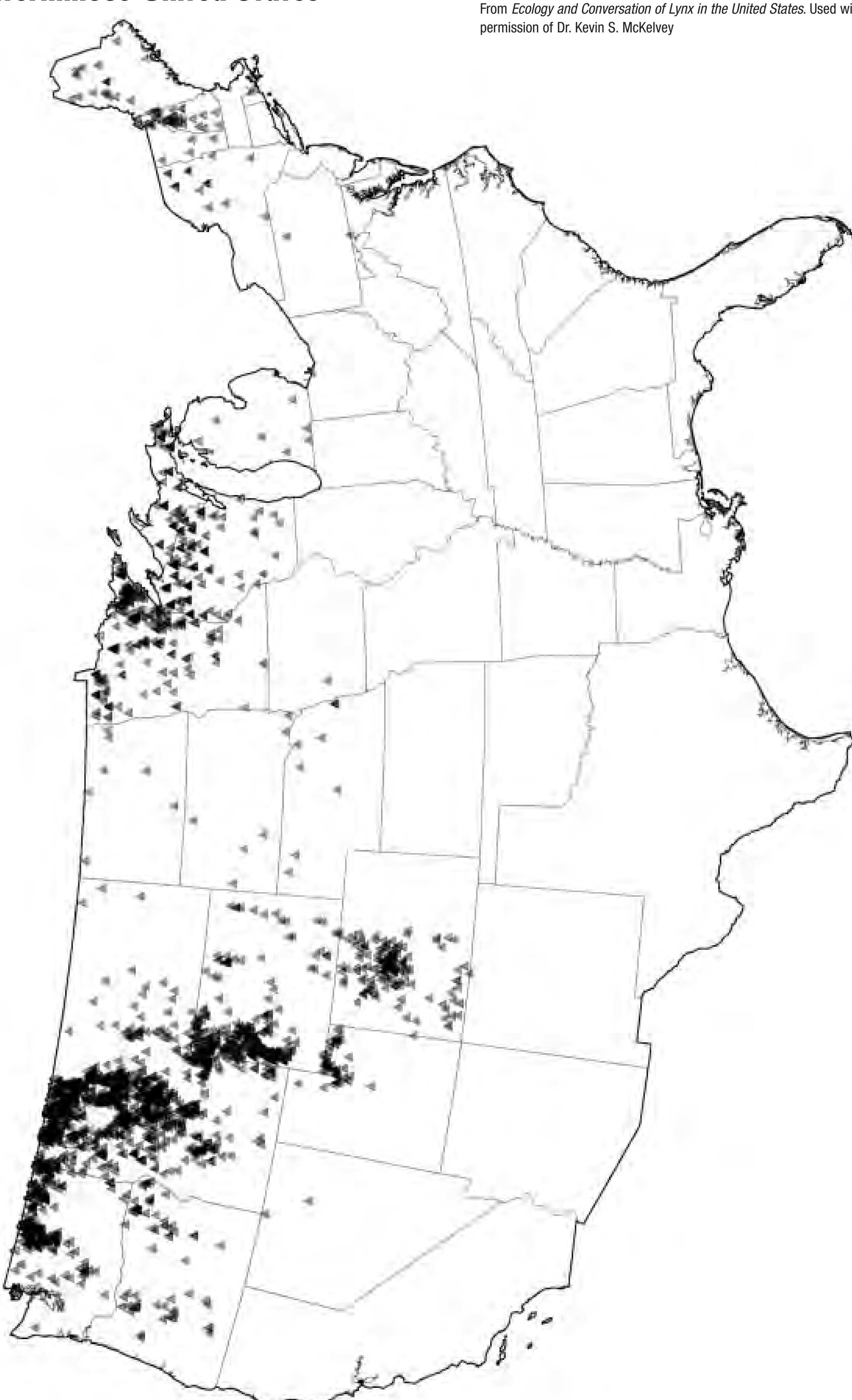
j. Was the metapopulation extirpated? ***Hopefully not, though it is remotely possible through random events.***

11. Construct a line graph showing all four populations over the 30-year period of time. ***Answers will vary.***

12. Historical records show that Colorado had a small “island” population of resident lynx. Beginning in 1999, the Colorado Division of Wildlife has captured and released lynx from Canada and Alaska and reintroduced them into Colorado in an effort to bolster its native lynx and re-establish a permanent successfully reproducing population. How is Colorado’s lynx reintroduction program similar to, and different from, the metapopulation dispersal/recolonization ideas presented in this activity? ***In some ways Colorado’s lynx reintroduction program artificially mimics those processes. Modern human activities (like highways) and habitat loss may contribute to blocking the natural dispersal and recolonization that used to happen. Also, by augmenting the lynx population on the Colorado “island,” there is an increased probability that the population will survive random negative events.***

Distribution of Lynx in the Conterminous United States

From *Ecology and Conversation of Lynx in the United States*. Used with the permission of Dr. Kevin S. McKelvey



Notes

Lesson 6

Student Pages

No Cat Is An Island

Boreal Forests and Lynx—The View from Space

Biomes are biological communities that cover large land areas and have similar climate and vegetation. If you were to try to map all the different biomes from space, you would notice something interesting. From a spaceship hovering over the North Pole, you would see a great ring of coniferous trees, mostly spruce and fir, circling the globe. These forests cover vast areas of Eurasia and North America and need cold, wet climates to grow. This biome, one of the largest on Earth, is often called by its Russian name, ***taiga***, but we know it as the boreal forest. Fingers of these forests extend southward where high mountains provide similar climate, conditions that are found in the Colorado Rocky Mountains

Lynx are ***circumboreal***—several species are found throughout these high latitude forests that circle the globe. The Canada Lynx *(Lynx canadensis)* is found in North America. The Eurasian or Siberian Lynx *(Lynx lynx)* was once found in the forested areas throughout most of Europe, the Middle East and Asia. Today the range of the cat has been drastically reduced and it is found primarily in Russia, Finland, Sweden, Norway, and throughout northern Asia. The Eurasian Lynx is larger than the Canadian Lynx. The Iberian Lynx *(Lynx pardinus)* is found in Portugal and Spain and—with less than 1,000 known animals in the wild—is critically endangered.

Colorado's Islands

An ***island*** is an isolated body of land. While we tend to think of a patch of land covered with palm trees and surrounded by ocean as an island, many types of islands exist on earth. An island could also be a large park in the middle of a city, or meadow surrounded by forests. The Rocky Mountains of the western U.S., the Cascade Mountains in Oregon, and the Adirondacks Mountains of New England all have peninsula-like extensions of spruce/fir forests. More and more, the habitat in these areas is broken up by human development such as highways, residential areas, snowmobile trails, cross-country trails, and ski runs. The remaining patches of boreal forest are like small islands located in a "sea" of land uses.

In North America, the northern and western provinces of Canada have large and healthy lynx populations. However, in the peninsular or island-like southern fringes like Colorado's Rocky Mountains, lynx populations are much lower. Not much is known about the ecology of these populations of lynx, and they offer a unique opportunity to research ***island biogeography***—the study of the distribution and population changes of species in an isolated ecosystem.

Island species are especially at risk of extinction. Their smaller geographic range and low population numbers make them more vulnerable to natural limiting factors such as disease, fire and normal population fluctuations. They are also more vulnerable to inbreeding, because there are fewer opportunities to get new genes.

Luckily, lynx in Colorado's Rocky Mountains are not completely isolated. These lynx are part of a ***metapopulation***—groups of ***subpopulations*** of lynx living on habitat patches (islands) separated from a larger ***source population*** of lynx in Canada. Over time, an island subpopulation may go extinct, but be ***recolonized***—reestablished—by future ***dispersing*** (traveling) lynx from other island or peninsula populations.

Reintroduction as a wildlife management tool imitates recolonization. In order to be successful, both reintroduction and recolonization require successful reproduction, not simply the presence of a species there. As long as more animals are added into an island population (***recruitment***), through immigration or reproduction, the metapopulation as a whole survives. However, if all of the islands' extirpation rate become greater than the recolonization rate, the entire metapopulation can face extirpation.

Lynx can disperse great distances, sometimes leaving the comfort of their cool forests to cross roads, rivers, and warm, snowless terrain. However, for a lynx to successfully disperse from the source population to an island it needs to be in good enough condition to survive the journey and it needs to travel in the right direction. It needs to avoid as many obstacles, such as roads or other hazards, as possible. Generally, more than half of dispersing animals die.

The Metapopulation Game

You are going to be playing a game that mimics dispersion and recolonization. You will need the maps you constructed from ***Lesson 3, Map That Cat***.

1. Using the map from *Map That Cat*, place four lynx tokens on each of these three island habitats:

- Central Colorado,
- Northeastern Utah (Uintah Mountains), and
- Northcentral Wyoming (Bighorn Mountains).

These represent very low-density, fragmented island populations with a very tenuous existence.

2. Place 25 lynx tokens in the peninsula created in Montana, Idaho, and northwestern Wyoming. This represents the medium-density peninsula population of lynx with stable numbers. Together with the island populations, these make up the lynx metapopulation in the United States.

3. Imagine hundreds of lynx tokens placed in Canada. These would represent the large, "mainland" population of lynx. The remainder of the lynx tokens can be placed in this source population "bank."

4. A flipped coin will be used to demonstrate the chance risks that these island and peninsula populations encounter in a year. Four members of your group will each adopt one of the four lynx populations: the peninsula and the three islands. Each will need a coin. One other member of your group will be the data recorder and one other will be the banker.

5. Upon the data recorder's command, flip all four coins simultaneously. A heads will represent an addition of one lynx to the population. A tails represents a loss of one lynx to the population. The banker will distribute or collect lynx as needed and the data recorder will record the "yearly" change (Each coin flip represents one year).

6. ***Continue as above for 10 years*** adding or removing the lynx tokens. Some island populations may be extirpated. If so, that member of the group should stop. The other members may continue the game as long as they have lynx in their population.

7. After ten years a unique event happens. Lynx in Canada are at the end of their cyclic high populations. Snowshoe hare populations are declining rapidly and lynx are beginning to starve. Lynx begin to disperse. Dispersal behaviors begin creating a ripple effect throughout the entire continent! To demonstrate this, the banker will add three lynx to the peninsula population; and three peninsular lynx will disperse southward. Most lynx dispersing long distances die; but a few survive to find adequate habitat. To demonstrate this, two of the dispersing lynx die (and get returned to the bank). One lynx survives and disperses to the island ***with the lowest number*** of lynx.

8. Continue playing the game for ten more years. The data recorder needs to keep accurate records. At the end of ten more years another cyclic dispersal event occurs. Repeat the same procedure as #7 above.

9. Continue playing the game for another ten years and stop.

10. Your group should have played for a total of 30 years. Answer/discuss the following questions thoroughly:

a. *Were any of the island populations extirpated?*

b. *Was that island extirpation due to a sequence of deliberate actions or random chance?*

c. *Did any of the island populations ever increase to over 10 lynx and maintain that number for more than 10 years?*

d. *If so, was that island's successful population due to a sequence of deliberate actions or random chance?*

e. *Did you find that once an island's population reached 10 lynx that it was not likely to later become extinct?*

f. *Was the peninsula population extirpated? Why or why not?*

g. *What was the effect of the lynx dispersal that occurred every 10 years? Did it help to successfully recolonize any of the islands?*

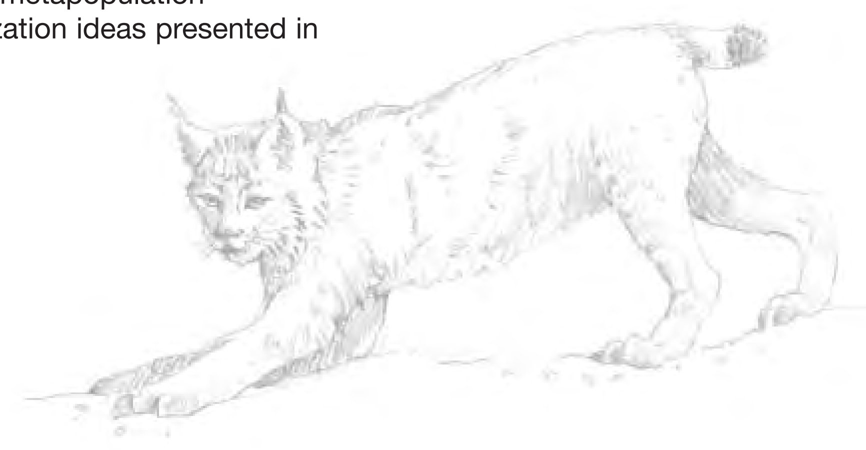
h. *In real life, could island recolonization occur with one lynx? Also, in real life, would a dispersing lynx automatically travel to the island with the least number of lynx?*

i. *In real life, how do you think distance would affect the probability of successful dispersal and recolonization of an island habitat? Can you relate that to Colorado's position on the map as related to the peninsula?*

j. *Was the metapopulation extirpated?*

11. Construct a line graph showing all four populations over the 30-year period of time.

12. Historical records show that Colorado had a small “island” population of resident lynx. Beginning in 1999, the Colorado Division of Wildlife has captured and released lynx from Canada and Alaska and reintroduced them into Colorado in an effort to bolster its native lynx and re-establish a permanent successfully reproducing population. How is Colorado’s lynx reintroduction program similar to, and different from, the metapopulation dispersal/recolonization ideas presented in this activity?



THE METAPOPULATON GAME CHART				
	NUMBER OF LYNX			
Year	Central Colorado	Northeastern Utah	Northcentral Wyoming	Rocky Mountain Peninsula
1	4	4	4	25
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
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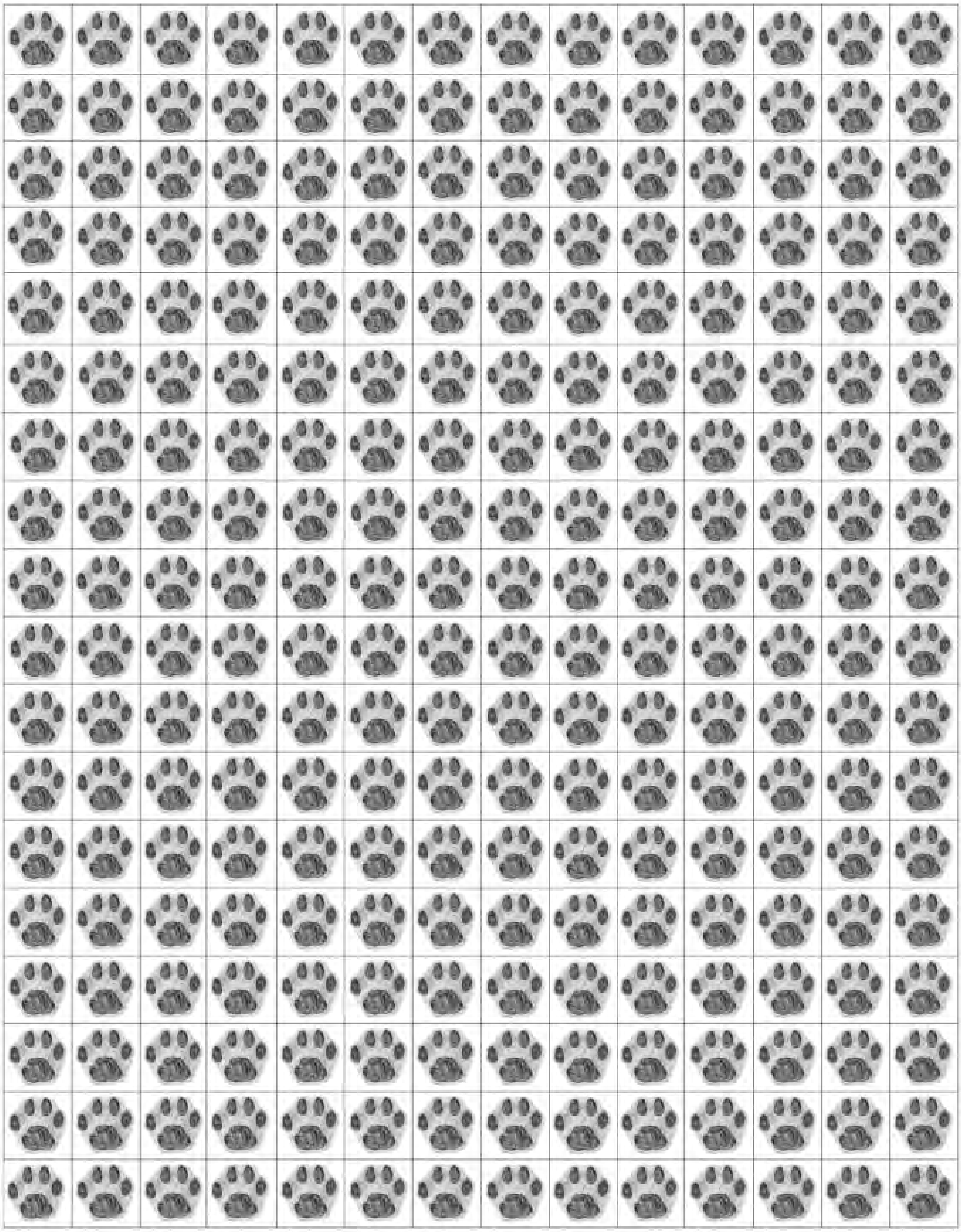


Notes

Lesson 7

Educator's Overview

It's A Plot!

Duration

Two 45-minute class periods

Vocabulary

Aerial search
Aspect
Backtrack
Blowdown
DBH (Diameter at Breast Height)
Deadfall
Home range
Mean
Mesic
Mortality signal
Overstory
Protocol
Radio telemetry equipment
Receiving system
Regenerating
Scat
Sign
Territory
Transmitting system
Understory

Summary

Student research teams construct habitat plots to evaluate features important to lynx. They compare their data to findings of DOW lynx researchers.

Learning Objectives

After completing this activity, students will be able to:

- Describe the use of radio telemetry equipment in lynx ecology research and distinguish between various transmitting and receiving systems.
- Set up a habitat plot.
- Use appropriate tools, technologies, and measurement units to gather, process, and analyze habitat data.
- Use graphs to compare results of their surveys with existing data.

Background

Most high school students understand the importance of good wildlife habitat and can describe its basic components—food, water, shelter, and space arranged in a way that can adequately support healthy populations. This activity introduces students to the technology and techniques that scientists use to get a deeper understanding of the habitat needs of a particular species—lynx—and demonstrates why this information is critical to Colorado's lynx reintroduction efforts.

Teaching Strategies

Note: *To best approximate lynx habitat and field methods used by DOW biologist, this activity would be done in the winter in an Englemann spruce/subalpine fir forest. However, since few schools are located near these forests, and since field trips may not fit with school budgets or time constraints, this activity can take place any time of year in any wooded habitat. If school grounds have no trees, try a local park or open space.*

1. Thoroughly read the student materials for *It's a Plot!*

2. Before introducing the activity, decide how many student research teams you will have and "mock-up" a corresponding number of field sites. Be sure you choose an area where you can set up one 12 meter x 12 meter plot for each student team, in the manner described in the student materials. To do so, you can write down the "use" the lynx has for that particular site on a card for the research team or you can get

creative with this. Create an artificial track line in the snow or dirt, throw a stuffed-toy rabbit splattered with red food coloring on the ground, form a lynx bed, etc.

3. Give each student a reading packet, but not the *Habitat Analysis* or *Lynx Daily Tracking Log and Site-Scale Habitat Evaluation* pages.

4. After giving students sufficient reading time, review the material. Talk about the need for various tracking technologies. Lynx travel extremely long distances in search of food or other needs. While satellite and aerial tracking help locate lynx, these methods cannot give researchers the information they need to understand how lynx use habitat. Only ground tracking and habitat evaluation can give scientists information about habitat features that are critical for lynx. ***Optional:*** If radio telemetry equipment is available, demonstrate how the equipment works. DOW staff may be able to assist you.

5. Discuss the importance of protocol in habitat evaluation. If each research assistant had a different method of evaluating habitat and recording their findings, the data could not be put together in a way that makes sense.

6. Divide students into research teams of three to four students. Tell each team that they are tracking a unique lynx and have found a site that looks important for lynx.

7. Give each student a *Lynx Daily Tracking Log and Site-Scale Habitat Evaluation* form. Tell students that they will be evaluating the habitat site and will later compare their findings with other lynx researchers. Ask each student team to gather the materials they need to set up and evaluate their plot: Tape measure with metric and English scale, pole or stick that is 150 cm in length or longer, 28 garden stakes or posts, compass, hammer, calculator, and piece of string, 65 meters in length.

8. Take student teams to their habitat sites and let each team set up their plot and record information.

9. After students complete the *Lynx Daily Tracking Log and Site-Scale Habitat Evaluations* form, give each student the *It's a Plot! Habitat Analysis* activity sheet. Give students time to complete the activity and discuss the findings as a class.

Assessment

- Students write a paragraph discussing the importance of using research protocols to build a body of scientific knowledge.

Extensions

- Explore succession in the spruce/fir forest and relate successional stages to lynx habitat needs.
- Modify the field exercise to gather habitat information for a different species.
- Students can calculate the averages (means) of the class findings and compare those to the researchers' results for year three.

Materials and Preparation

- *Wooded area, in spruce/fir forest, school grounds, park or local open space*
- *Student reading pages for* It's a Plot!*, one per student*
- *Student activity page* It's a Plot! Habitat Analysis*, one per student*
- *Student data form* Lynx Daily Tracking Log and Site-Scale Habitat Evaluation*, one per student*
- *Tape measure with metric and English scale, one per student team*
- *Pole or stick that is 150 cm in length or longer, one per student team*
- *Garden stakes or posts, 28 per student team*
- *Compass, one per student team*
- *Hammer, one per student team*
- *String, 65 meters in length, one per student team*
- *Calculator, one per student team*
- ***Optional:*** *Key to trees and shrubs of the area*
- ***Optional:*** *Topographical map of the area*
- ***Optional:*** *"Props" of various kinds, such as stuffed toy rabbit, red food coloring, etc.*
- ***Optional:*** *If available through your DOW office, a radio transmitter and receiver*

Key

Completion of the *Lynx Daily Tracking Log and Site-Scale Habitat Evaluation* form and answers to questions 1 through 4 will vary, since each habitat plot will be different.

5. a. What was the most common understory species in habitat used by lynx in year three? ***Engelmann spruce.***

   b. What was the most common understory species in your habitat? ***Varies.***

   c. What was the most common overstory species in the plots sampled by researchers in year three? ***Engelmann spruce.***

   d. Which species, if present in a plot, provided the most cover in a plot? ***Lodgepole pine.***

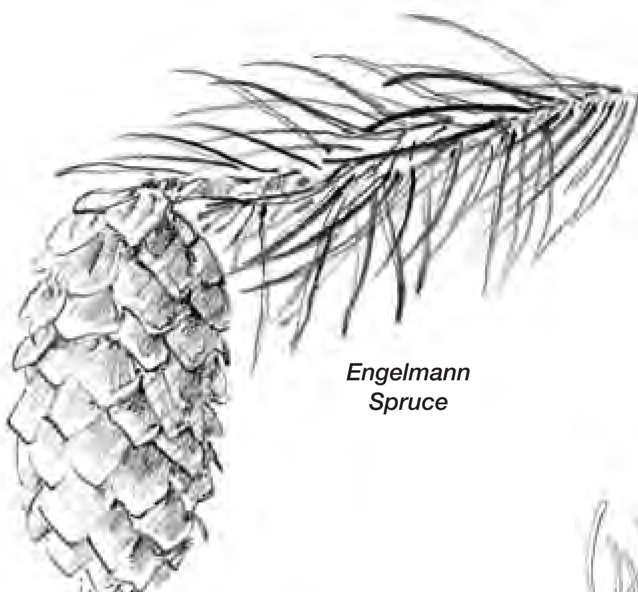
   e. What was the most common overstory species in your habitat plot? ***Varies.***

   f. What two trees are most commonly found in the habitat plots in year three? ***Engelmann spruce and subalpine fir.***

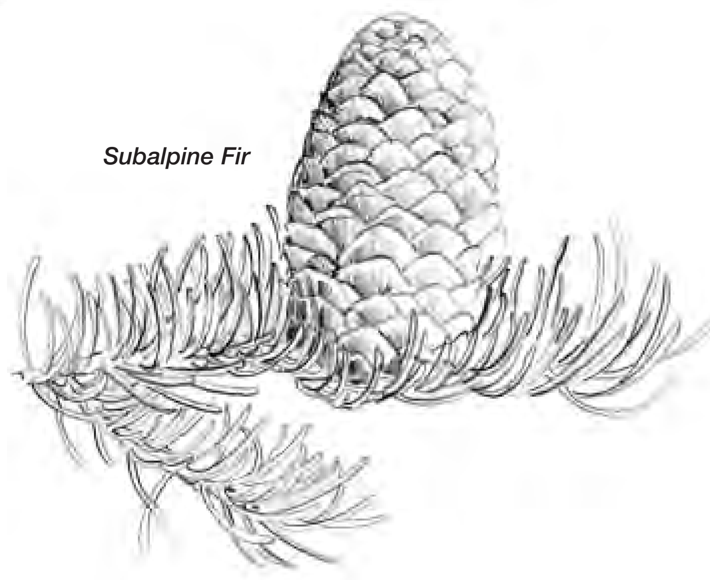
   g. In general, were these young trees or old trees? How do you know? ***They may be younger trees because the DBH is generally small. However, Colorado has a dry, cold climate and trees do not grow as quickly or as big as in other places. The only way to know for sure would be to do core sampling of the trees.***

   h. What were the two most common trees found in your habitat plot? ***Varies.***

   i. Why do researchers collect so much information about sites where lynx hunt, rest, den, and mark territories? How will they apply their findings to management practices? ***Through careful analysis of this data, researchers may be able to determine habitat characteristics that lynx prefer. As managers, they can work with private and public landholders to conserve important lynx habitat.***



Engelmann Spruce



Subalpine Fir

Notes

Lesson 7

Student Pages

It's A Plot!

In general, biologists know that lynx live in spruce/fir forests and that those forests have different dominant trees in different regions (see Lesson 3, Map that Cat). Lynx are abundant in some of these forests, and scarce in others. Even when the population goes bust in British Columbia, lynx are not rare. Colorado, on the other hand, has thousands of square miles of spruce/fir forests, yet historically, has never had huge populations of lynx. Why is that? What elements of the habitat are critical for lynx survival?

Most of what scientists know about lynx ecology comes from research in the far northern part of its range, from Canada and Alaska. In these areas, lynx prefer ***regenerating*** forest stands more than 20 years old rather than mature forests. The dense understory of these stands provides food, cover, and protection for snowshoe hare—the cat's favorite food. In addition, lynx use ***blowdown*** and ***deadfall*** trees in this habitat for dens. Usually, males have a larger ***home range*** (the area an animal travels in the scope of its normal activities) than females. Both females and males set up ***territories***—areas they defend against others of the same species. Breeding male and female pairs have territories that almost completely overlap, but lynx of the same sex rarely share territory.

Colorado's habitat is not like Canada's or Alaska's. Therefore, biologists do not know if lynx have the same habitat needs at the southern end of their range as in the far north. Colorado spruce/fir forests are higher in elevation, more isolated, and more ***mesic*** (drier). Since there is less moisture, forest regeneration is slower here. Lynx have been missing from Colorado for quite some time. The reintroduction provides researchers with a great opportunity to increase their knowledge, and in turn, accurately define the management options that will enhance lynx survival here.

Follow that Cat!

So how in the world can a researcher find out how big a male lynx's home range is in Colorado? Or what its diet is? Or whether it has a mate? Is the researcher just supposed to follow the cat around day and night? Yes, pretty much!

Running after a lynx in deep snow would be pretty irritating to the cat, and exhausting, if not impossible, for the researcher. Luckily, there is a technological solution to this problem. Animal movements are determined through aerial or satellite monitoring and more detailed information is gathered from on-the-ground snow tracking.

Radio telemetry collars (VHF) have been used on lynx since the first animals were released in February 1999. ***Radio telemetry equipment*** consists of two parts, a ***transmitting system*** and a ***receiving system***. The collar is the transmitting system, which includes a *radio transmitter*, a *power source* (battery) and *antenna*, all contained in one compact unit. Each collar has its own frequency similar to a radio station frequency. The collars are also equipped with motion sensors that tell researchers the cat is physically active. If the sensor detects that an animal has not moved for an extended period, usually four hours, a faster signal is emitted by the transmitter. This is a ***mortality signal***, indicating that the animal may be dead.

The receiving system includes both a directional *antenna* and a *receiver*. The receiver is set to a specific frequency, and if the operator is within range, he or she should hear a beeping signal.

VHF collars require an aircraft to fly within a few miles of an individual cat to pick up its distinctive signal. This can be difficult because lynx cover so much ground. Sometimes the animal will go down behind a ridge or in a canyon, which can make it difficult to pick up its signal. Since April 2000, lynx were fitted with collars that contain both tiny radio and satellite transmitters. The satellite transmitters provide approximate lynx locations on a weekly basis. The DOW can then hone in on a specific lynx by airplane using the VHF radio signal broadcasted by the collar.

Tuning in to LYNX 99.5

In order to determine the exact location of a lynx, researchers begin with a broad ***aerial search***. The single-engine DOW aircraft has an antenna mounted on the outside to track each lynx signal and determine its approximate location. To locate a radio-collared lynx from the air, the pilot flies over suspected lynx territory while the researcher listens for a signal. When the researcher hears the beeps, the pilot will drop down and circle the area. From the air, the pilot and researcher on board will make a visual reading of the vegetation, whether it is spruce/fir or aspen or other vegetation, the elevation and which direction the slope faces.

Then, the on-the-ground tracking efforts begin. The primary purpose of ground tracking is to obtain information that can't be gathered through the aerial tracking efforts. By following lynx tracks, researchers gather information about each animal's day-to-day behavior and other important clues in discovering how lynx are adapting to Colorado's climate, and what habitat conditions and prey species they prefer.

Making Tracks

Winter is the best time to collect data because lynx tracks are easy to identify in the snow. When tracking lynx on the ground, the researcher must first locate the animal using an antenna and receiver. After picking up a signal, she straps on snowshoes and hikes through the dense forest to locate the lynx tracks. The DOW's lynx tracker is careful not to get too close to the lynx she is tracking. Once she spots its tracks, she ***backtracks***—hikes along the tracks away from the cat. The tracker then documents any scat, fresh kills and hunting beds. Typically, if she finds scat near the lynx tracks, she backtracks and looks for a day bed where the animal may have rested after making a kill. Just like humans, a lynx will eat, take a nap and then defecate. All of this information helps to further define the habitat requirements and prey preferences for lynx in Colorado.

If researchers pick up a mortality signal during the aerial search, ground trackers try to recover the animal as soon as possible. They search the immediate area for signs of other predators and take a photograph of the carcass before moving it. The researchers then take the dead lynx back to the lab to determine the cause of death. They keep detailed records of mortalities and overall survival rates of the reintroduced lynx. This information may lead to changes in management efforts.

Signs

Lynx trackers become skilled at reading tracks and other lynx ***sign*** (any indication of an animal's passage through or use of an area). Some signs show lynx just moving through. These might be ***scat*** (feces) along a track or short duration beds (an indentation in the snow where a lynx would crouch or rest briefly). Other sites seem more important for lynx. Certain types of habitat use usually mean that there are features in the habitat that lynx select (prefer). These could include:

Hunting Behavior

- Start of Chases (both successful and unsuccessful)
- Kills

Long Duration Beds

- (places where a lynx would have lain long enough for its body heat to melt snow, usually a depression with ice at the bottom)

Territory Marks

- Scat (buried or placed in a prominent place)
- Scenting (spray)

Road Crossings

Dens

Following Protocol

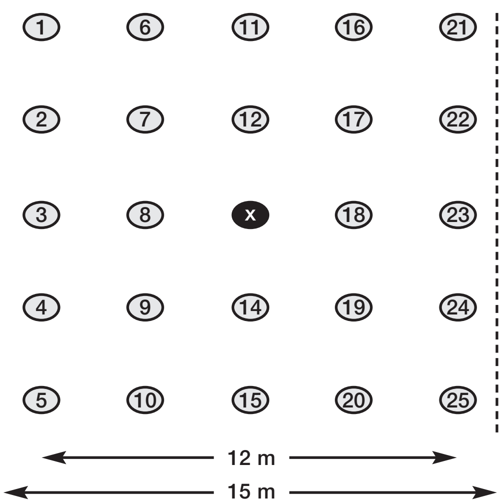
To be useful, the data that researchers collect about the habitat in these areas has to be consistent—documented in the same way each time. When each researcher follows the same ***protocol*** (plan) to collect and record data, the data can provide reliable information about lynx ecology in Colorado.

Every time researchers discover an important lynx habitat-use site, they record information about that site. First, the researchers record general information about the site including:

- ***Date*** and ***Time*** of the find.
- ***Lynx*** being tracked (each has its own ***number***)
- ***Location*** (county, forest name, UTM or latitude/longitude from a map)
- ***Elevation*** (from map)
- ***Slope***
- ***Aspect*** (the direction of "downhill"—using a compass)
- ***General Habitat Description*** (a description of the plants found at the site such as grasses and forbs, shrubs or seedlings, saplings, mature trees, etc.)
- ***Trackers*** (the names of the researchers)
- ***Habitat Use*** (what was found there—scat, bed, kill, etc.)
- ***Other Animal Species*** (check if other tracks or signs visible)
- ***Human Activity*** (*None* if track was not found off an existing snowmobile, ski, or snowshoe track and the distance to nearest human track is greater than 1.0 km; *Low* if track was found near low human activity such as existing snow-mobile or ski track; *Medium* if track found near medium human activity where the presence of other people in

the area was detected during tracking effort; or *High* if track found near high human activity including detecting presence of many people nearby, near major road, or near housing).

Then, researchers set up a habitat-sampling plot. The plot is a 12 meter x 12 meter square with a series of 25 points placed in five rows of five. Each point is three meters apart. The object that triggered the habitat sampling, such as a bed or a kill, is at the very center point of the plot.



Researchers take measurements at each of the 25 points including:

- ***Snow depth (SD)***—This is measured vertically in centimeters.

Plant Species	CODE
Englemann Spruce	ES
Subalpine Fir	SF
Willow	WI
Aspen	AS
Lodgepole Pine	LO
Coarse Woody Debris	CWD

- ***Understory***—This is measured holding a pole from the top of snow to 150 cm above the snow. At each point, researchers record all species of shrubs, trees and coarse woody debris (CWD) that touch the pole (or are within 2 inches of it) and are visible above the snow. This information is recorded for each species at three different height ranges (0–0.5 m, 0.51–1.0 m, 1.01–1.5 m). Researchers use a two or three-letter code to identify the plant species. They list the code once for each height range like this:

Point	Snow Depth (cm)	# Understory Hits by Species/Height 0–0.5 m	0.5–1 m	1–1.5 m	Overstory Species
1		ES, WI, CWD	ES, AS	ES, SF, AS	
2					
3					

- ***Overstory***—This is measured with a sighting tube that is somewhat like a periscope. It is a curved piece of PVC pipe with a viewing end and a crosshair made of wire on the other end. The objective is to record what species of trees (branches) are directly above the point. If no special equipment is available, the biologist looks straight up.

- ***Trees by DBH Class***—Finally, all the trees in the habitat plot are recorded. Both live and dead trees (snags) are counted. The researcher records the species of tree and its diameter at breast height (***DBH***). To be consistent, DBH is measured at four feet above ground. DBH is measured in inches.

Number of Trees by DBH Class

Species	A (0–6")	B (6.1–12")	C (12.1–18")	C (18.1–24")	E (>24")
ES	6	2	4	3	1
ES Snag	0	0	0	1	0

Lynx Daily Tracking Log and Site-Scale Habitat Evaluation

Date: ________ Lynx ID: ____________ Time: ________

Site Location: ______________________________

Slope: ________ Aspect: ____________ Elevation: ________

General Habitat Description: ______________________________

____

____

____

Trackers: ______________________________

Habitat Use: ______________________________

____

____

Other Animal Species:

- ❏ Bobcat
- ❏ Coyote
- ❏ Moose
- ❏ Squirrel
- ❏ Fox
- ❏ Elk
- ❏ Deer
- ❏ Weasel
- ❏ Snowshoe Hare
- ❏ Pine Marten
- ❏ Mountain Lion

Other, list: ______________________________

Human Activity: (H = High M = Medium L = Low N = None)

________ Activity: ______________________

________ Activity: ______________________

________ Activity: ______________________

________ Activity: ______________________

Summary: ______________________________

____

____

____

____

____

Point	Snow Depth (cm)	# Understory Hits by Species/Height 0–0.5 m	0.5–1 m	1–1.5 m	Overstory Species
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Number of Trees by DBH Class

Species	A (0–6")	B (6.1–12")	C (12.1–18")	C (18.1–24")	E (≥24")

Comments: ______________________________

____

Habitat Analysis

It's A Plot!

While following lynx number ___, your research team has come across a site that was used by the feline in a specific way. Set up a study plot and complete the Lynx Daily Tracking Log and Site-Scale Habitat Evaluation form. You may have other tree species than those listed, so feel free to make up your own two-letter code for each species.

After you have completed the habitat evaluation and completed the form, you will need to analyze the information.

1. ***Compute Average Snow Depth:***

If your site had snow, determine the average depth and the variance.

Average: Sum of all snow depths taken at each point ÷ 25 points

____

Variance: The shallowest and the deepest measurements

____

2. ***Analyze Understory Data***

   a. Determine the ***Percent Occurrence of Understory Vegetation***. To do this, add together the number of points that had an understory and divide that sum by the total points surveyed (25). For example, if 5 of your 25 points had understory, that would be 20 percent occurrence.

   b. Now, determine the ***Percent Occurrence of Understory Vegetation by Plant Species*** for each ***Height*** (low is 0–50 centimeters above ground or snow, medium is 0.51–1.0 meters above ground or snow, and high is 1.1–1.5 meters above ground or snow). For example, let's say that 10 of the 25 points had Engelmann spruce in the understory at low height (0–50 cm), then the percent occurrence of Engelmann spruce at low height is 40 percent.

	PERCENT OCCURRENCE OF UNDERSTORY VEGETATION BY SPECIES (SP)					
	Sp:	Sp:	Sp:	Sp:	Sp:	Sp:
Low Height						
Medium Height						
High Height						

3. ***Analyze Overstory Data***

For each species, determine the Percent Occurrence of the Overstory Vegetation. To do this, sum the number of points that had an overstory of that species directly above the point and divide that sum by the total points surveyed (25). For example, if your research team could look up and see subalpine fir overstory directly above 16 out of 25 points, then the percent overstory occurrence of subalpine fir would be 64 percent.

PERCENT OCCURRENCE OF OVERSTORY VEGETATION BY SPECIES (SP)					
Sp:	Sp:	Sp:	Sp:	Sp:	Sp:

4. ***Analyze Tree Composition of Plots***

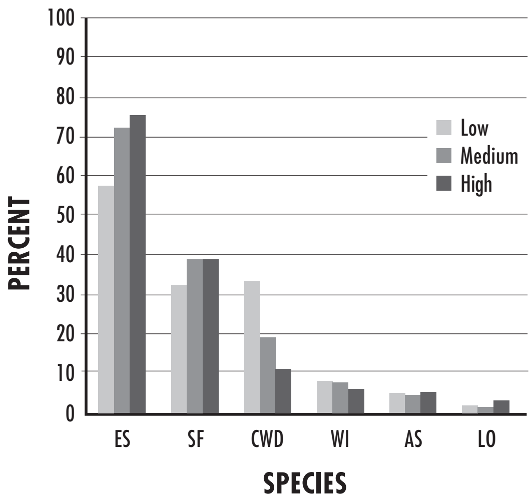
Tree Composition is the mix of trees that are actually growing in the study plot. Transfer the information from your *Site-Scale Habitat Evaluation* form to this table.

	TREE COMPOSITION					
	Sp:	Sp:	Sp:	Sp:	Sp:	Sp:
0–6" DBH						
6.1–12" DBH						
12.1–18" DBH						
18.1–24" DBH						
>24" DBH						

5. ***Compare Your Results***

In year three of the lynx reintroduction, researchers completed 473 site-scale habitat plot evaluations. They used their information to compile several graphs:

Understory

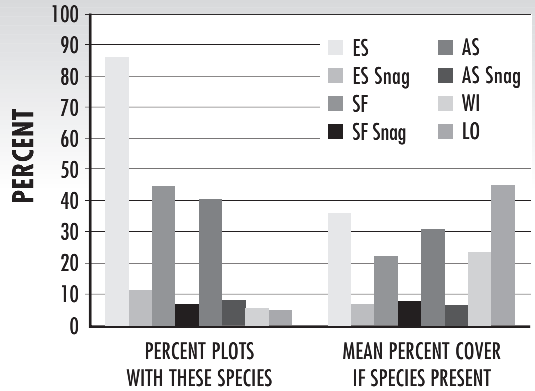


Mean (average) percent cover of habitat plot by understory tree/shrub species Engelmann spruce (ES), subalpine fir (SF), willow (WI), aspen (AS), lodgepole pine (LO), and coarse woody debris (CWD). Mean percent cover is estimated for 3 height levels above the snow.

a. *What was the most common understory species in habitat used by lynx in year three?*

b. *What was the most common understory species in your habitat?*

Overstory



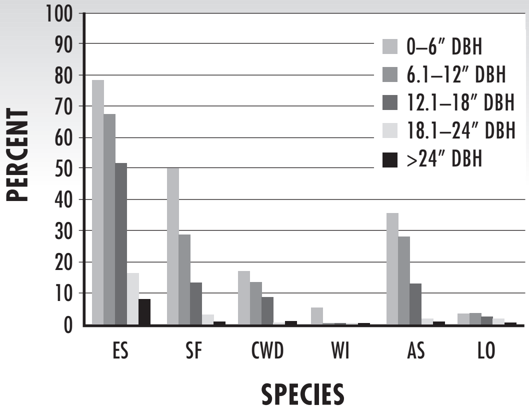
Percent plots with overstory tree species Engelmann spruce (ES), subalpine fir (SF), willow (WI), aspen (AS), lodgepole pine (LO), and coarse woody debris (CWD). Mean percent overstory cover if tree species present.

c. *What was the most common overstory species in the plots sampled by researchers in year three?*

d. *Which species, if present in a plot, provided the most cover in a plot?*

e. *What was the most common overstory species in your habitat plot?*

Tree Composition



Percent of habitat plots with tree species Engelmann spruce (ES), subalpine fire (SF), willow (WI), aspen (AS), lodgepole pine (LO), and coarse woody debris (CWD) by diameter at breast height (DBH) size class.

f. *What two trees are most commonly found in the habitat plots in year three?*

____

____

g. *In general, were these young trees or old trees? How do you know?*

____

____

____

____

h. *What were the two most common trees found in your habitat plot?*

____

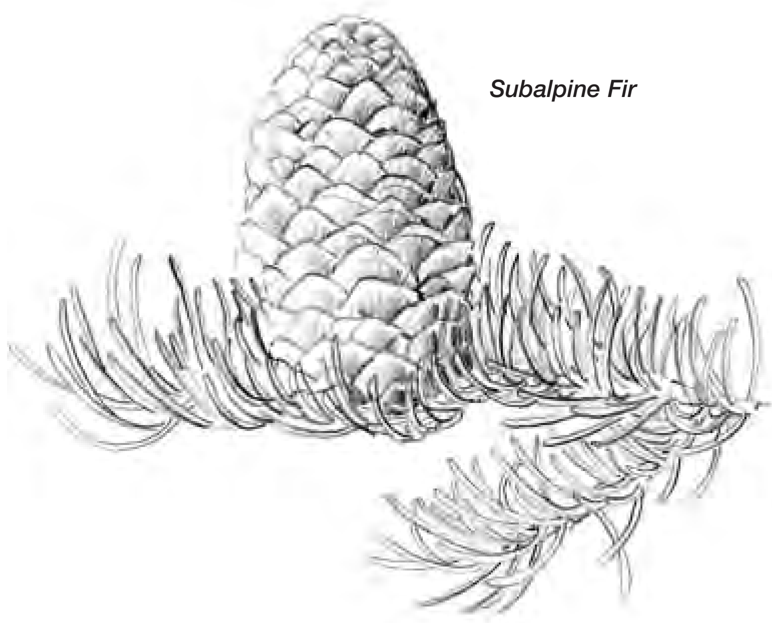
i. *Why do researchers collect so much information about sites where lynx hunt, rest, den, and mark territories? How will they apply their findings to management practices?*

____

____

____

____



Subalpine Fir

Notes

Lesson 8

Educator's Overview

Seven Steps To Success

Summary

Students retrieve new and archived information from the Colorado Division of Wildlife Web site to document achievements in lynx reintroduction efforts.

Duration

One 45-minute class period

Vocabulary

Fidelity

Recruitment

Learning Objectives

After completing this activity, students will be able to:

- Describe the seven indicators of a successful species reintroduction program.
- Provide evidence of milestones towards lynx recovery.
- Present an overview of the lynx reintroduction effort in a written or oral format.

Background

Since the lynx reintroduction effort is a current scientific endeavor, new information is continually available on the Colorado Division of Wildlife's Web site. In this activity, students gather the latest data on the project and discuss the status of the recovery effort. As the closing activity, students review what they have learned about lynx and the reintroduction effort and present an overview of the entire unit in a written or oral format.

Teaching Strategies

1. Thoroughly read the student materials for *Seven Steps to Success*.

2. Give each student a reading and activity packet.

3. After giving students sufficient time to read the packet, assign the questions to individuals or groups.

4. As a class, discuss the answers. Colorado's efforts to bring back the lynx are currently achieving many milestones. Recommend that students check the Web site periodically to follow this historic effort.

5. Revisit the questions that students developed for *Lesson Two, Planning the "Purrrfect" Comeback*. Do students have any questions left unanswered? If so, ask students to check the DOW Web site again and answer those questions.

Assessment

- Students, as individuals or in groups, should present an overview of all they have learned about the lynx reintroduction in a written or oral format.

Extensions

- Students can research other lynx reintroduction efforts, or efforts to reintroduce other species, and compare the results of those efforts to the lynx project.

Key

1. Was the first lynx release protocol successful? Why or why not? If any changes were made, what were they? In what year did biologists have a successful release protocol? ***The first year, too many of the newly released lynx died of starvation. After carefully monitoring and analyzing the situation, biologists devised a new release protocol. Lynx now acclimate in pens in Colorado for at least a month, they are well fed and their health is closely monitored. Release now occurs after April 1 when the lynx are in peak condition and when food sources are abundant and easily captured. The second year of the program, 2000, is considered the year when biologists had a successful release protocol.***

2. What is the current status of lynx in Colorado? Find the information on the Web site to complete these charts: ***Answers to charts will change each year. Updates on lynx status are posted on the Colorado Division of Wildlife's Web site.***

3. What do the charts and other information posted on the Web site tell us about fidelity? Are most lynx staying in the research area? ***Most of the lynx known to be alive are in the research area, so they have developed fidelity to the research area.***

4. Has there been evidence of breeding or reproduction? If so, complete this chart with the most current information: ***There is evidence of breeding and reproduction. The first kittens were found in 2003. Answers to the chart will change each year. Updates on lynx status are posted on the Colorado Division of Wildlife's Web site.***

5. What evidence, if any, is there of recruitment of Colorado born kittens to the breeding population? ***2005 is the first year that kittens born in Colorado will be able to breed. Stay tuned to the Web site for the latest news on this issue.***

6. Is there a viable population of lynx in Colorado? When do you predict there will be? ***No, as of 2005, there is not a viable breeding population of lynx in Colorado. Predictions will vary. Look for a logical response.***

Materials and Preparation

- *Access to the Internet (from classroom, school computer center, local library, or home)*
- *Student Reading and Activity Pages for* Seven Steps to Success, *one photocopy per student.*

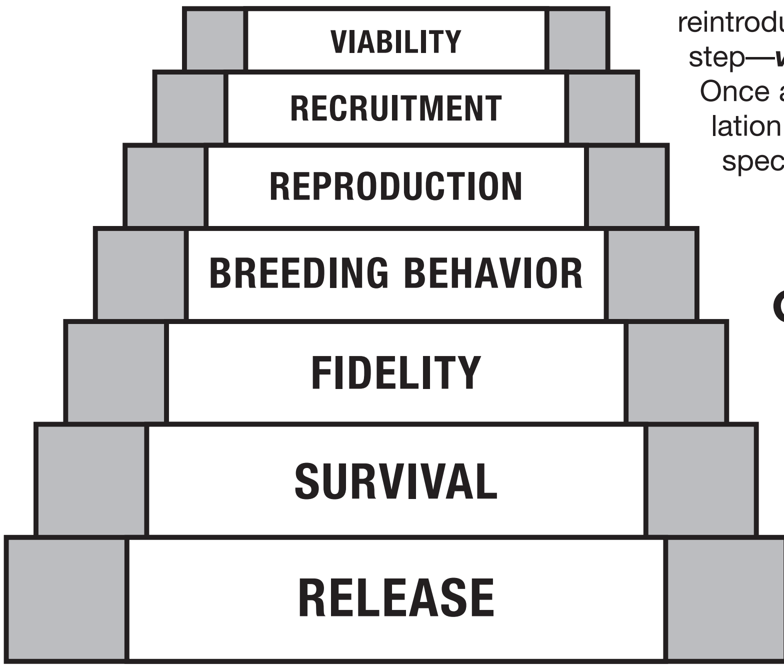
Lesson 8

Student Pages

Seven Steps To Success

The Seven Steps to Success

It is said that a journey of a thousand miles begins with a single step. The same thing can be said about species recovery. It can be a long and arduous process. Seven huge, important steps must be achieved before the lynx reintroduction in Colorado is considered successful.



The first step is to ***develop successful release protocols*** that ensure the highest probability of survival for each individual lynx released. Next, introduced lynx must be able to ***survive*** for extended periods in the wild. Third, the lynx must develop ***fidelity*** to a specific area—they have to remain in the area where biologists want to reestablish a population. Then, biologists look for evidence of ***breeding behavior***. They look for males and females to establish overlapping territories and be observed spending time together. The fifth step is ***reproduction***—kittens are born. If these kittens survive, mature, and produce young of their own, they add to the new lynx population—a term biologists call ***recruitment***. Finally, when lynx recruitment exceeds mortality, and there are enough breeding age lynx so that there is no need for wildlife managers to reintroduce any more lynx, the seventh step—***viability***—has been reached. Once a self-sustaining viable population of lynx roams Colorado, the species is considered recovered.

Celebrating Success

Biologists, and indeed many other Coloradans, celebrate each milestone on the road to lynx recovery. Usually, they want the entire world to know all about it. Press releases are sent out and usually television, radio, and newspapers broadcast the latest achievement.

Many of the seven steps have already been achieved. You can track the progress towards a viable lynx population on the Colorado Division of Wildlife's Web site http://wildlife.state.co.us using the same procedures you used in *Lesson Two, Planning the "Purrfect" Comeback* for Lynx. Scan the "News & Media" section to answer the following questions.

1. *Was the first lynx release protocol successful? Why or why not? If any changes were made, what were they? In what year did biologists have a successful release protocol?*

2. *What is the current status of lynx in Colorado? Find the information on the Web site to complete these charts:*

CAUSE OF DEATH FOR ADULT LYNX RELEASED INTO SOUTHWESTERN COLORADO SINCE 1999

Cause of Death	Number of Mortalities
Unknown	
Starvation	
Hit by Vehicle	
Probable Hit by Vehicle	
Shot	
Probable Shot	
Probable Predation	
Other Human Caused	
Plague	
Illness	
Total Mortalities	

STATUS OF ADULT LYNX REINTRODUCED TO COLORADO SINCE 1999

	Females	Males	Unknown	TOTALS
Released				
(-) Known Dead				
(=) Possibly Dead				
Missing*				
Tracking				

*Researchers cannot pick up radio signals from missing lynx and do not know the locations of these animals. Either their collar batteries have died or the collars are still functioning and the lynx have moved outside the research area.

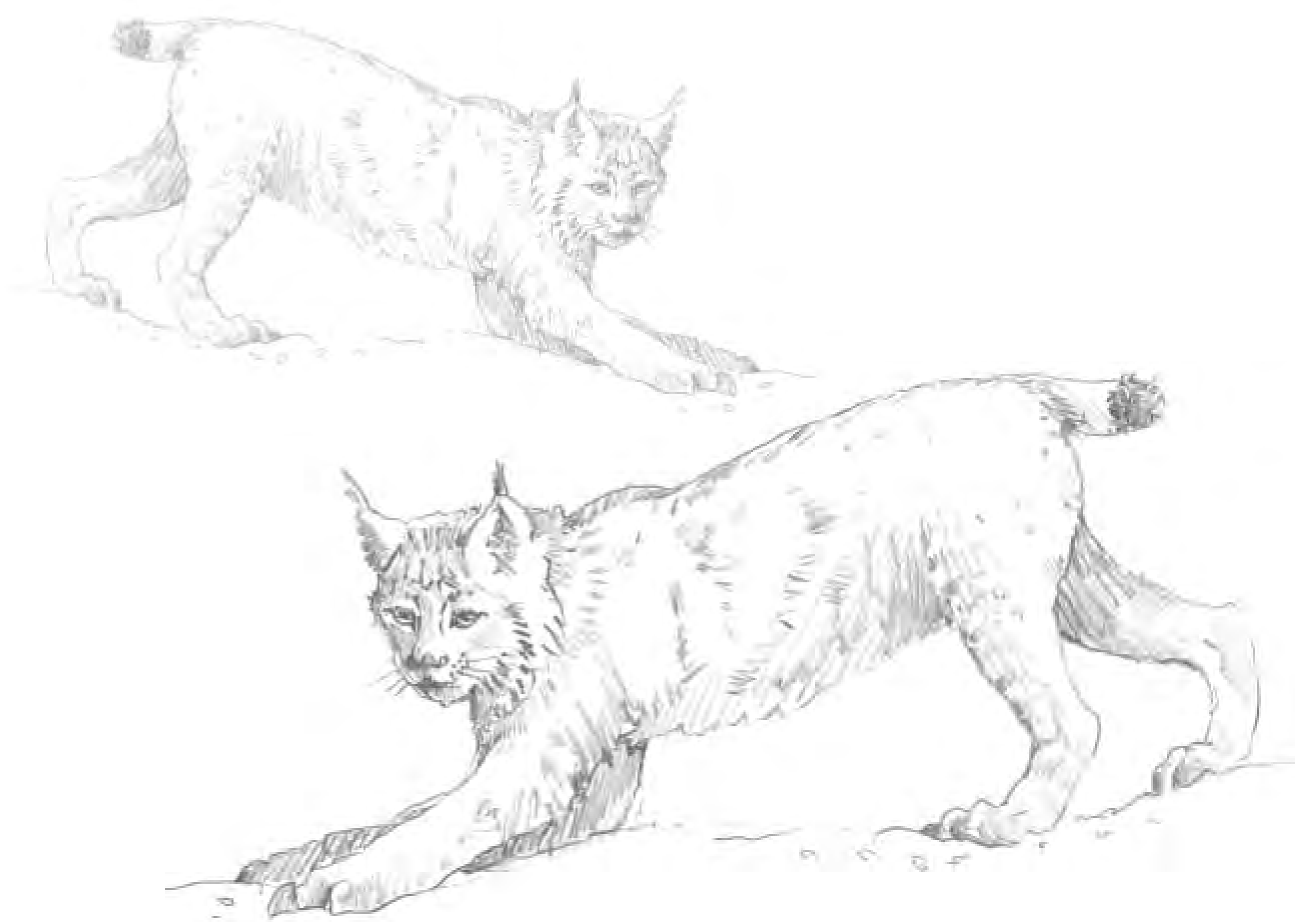
3. What do the charts and other information posted on the Web site tell us about fidelity? Are most lynx staying in the research area?

4. Has there been evidence of breeding or reproduction? If so, complete this chart with the most current information:

Female ID	Release Year	Previous Litters (Year/Number of Kittens)	Number of Kittens		
			Males	Females	Total
Total					

5. What evidence, if any, is there of recruitment of Colorado born kittens to the breeding population?

6. Is there a viable population of lynx in Colorado? When do you predict there will be?



Glossary

Aerial search: a search for an animal using an aircraft

Adaptation: anatomical, physiological, or behavioral changes that improve a population's ability to survive

Backtrack: to hike along the animal tracks in the opposite direction that the animal is moving

Bag limit: legal allowance of a specified number of fish or animals that can be harvested within a certain time limit

Biogeography: the study of the distribution and population changes of a species

Biome: a community with distinct vegetation and climate

Biotic potential: maximum rate at which the population of a given species can increase when there are no limiting factors

Blow down: trees pushed down by wind or storms

Boreal: the northern-most broad band of mixed coniferous and deciduous trees that stretches across North America, Europe, and Asia

Browse: twigs, leaves, and plants or shrubs that are fit for animals to eat

Candidate species: federal designation for species that are at risk of becoming threatened or endangered

Carnivore: meat eater

Carry capacity: the number of individuals of a species that a given environment can support

Census method: a method used to count the number of a certain population

Circumboreal: high latitude forests that circle the globe

Circumpolar: circling the North Pole

Colonization: to establish a population in a new location

Colorado Division of Wildlife (DOW): state agency devoted to protecting and preserving Colorado's wildlife

Competition: rivalry between two animals over demand for limited resources such as, territory, food, opposite sex

Control group: a group that receives no experimental treatment

Controlled experiment: a scientific investigation during which an experimental group is compared to a control group

Conterminous 48 States: all U.S. states excluding Alaska and Hawaii

Cover type: type of plants found at a location

Deadfall: dead trees that have fallen down in the forest

Density: number of individuals in a certain area

Dependent variable: variable that is measured

Dispersal: to travel somewhere else

Distribution: how individuals are arranged in an area

Emigrate: when individuals move out of a population

Endangered: at risk of becoming extinct

Endangered Species Act (ESA): a federal law passed in 1973 that seeks to prevent plants and animals from becoming extinct in this country

Experimental group: a group that receives some type of experimental treatment

Extirpated: missing from native range, but not extinct

Extinct: no longer exists

Features: physical characteristics

Fidelity: staying in a particular area; establishing a home range

Foot loading: body weight to foot-surface area ratio

Forbs: flowering plants

Game animal: animals that people can legally hunt, trap, or fish

Generalist: species which utilize a broad range of habitat components to meet their needs (such as eating a wide variety of prey)

Habitat: the arrangement of food, water, cover and space suitable to an animals needs

Harvest: to take animals by hunting or trapping

Herbivore: plant eaters

Home range: the area an animal travels in the scope of its normal activities

Hypothesis: an explanation that may be true, and can be tested by additional observations or experimentation

Immigrate: when individuals move into a population

Independent variable: the factor that is changed in an experiment

Indigenous: living or occurring naturally in an area; native to that area

Island: isolated body of land

Island biogeography: the study of the distribution and population changes of species in and isolated ecosystem

Leveret: baby snowshoe hare

Limiting factor: anything that limits the growth of the population

Mesic: dry

Mesocarnivore: mid-sized meat eater

Metapopulation: groups of subpopulations of a species living on habitat patches (islands) separated from a larger source population

Model: an imitation of the key characteristics of a real population

Mortality signal: a signal on radio telemetry equipment that indicates that the animal being tracked has not moved in a given time period and may be dead

Natural resource: raw materials supplied by the Earth and its processes such as, minerals, state lands, parks, oil and gas, forests, water and wildlife

Niche: the function of a species in an ecosystem

Observation: information obtained by using the senses

Overstory: the top forest layer formed by the leaves and branches of trees

Pelt: preserved animal skin or fur

Peninsula: an extension of a specific ecosystem, often surrounded on three sides by dissimilar ecosystems

Population: all the individuals of a species that live in a particular place at a particular time

Population dynamics: changes in density, size, and dispersion of a population

Population model: a model that allows scientists to predict how a population will change

Predator: an animal that kills and eats other animals

Prey: animals that are hunted for food

Protocol: a plan of how to do something

Radio telemetry equipment: equipment used to track animals remotely

Receiving system: part of the radio telemetry equipment used by the operator, which is set to a specific frequency so that if the operator is in range of the animal, he or she should hear a signal from the transmitting system

Recolonization: the process of reestablishing subpopulations in areas the species previously occupied

Recovered: populations large enough and healthy enough to be self-sustaining in the wild

Recovery plan: a plan developed to recover threatened or endangered species

Recruitment: animals being added to a population

Regenerating: reproducing; re-establishing

Reintroduction: an attempt to re-establish a species in an area that was once part of its historical range, but from which it has been extirpated

Scat: feces left by an animal

Season: certain times of year people may hunt or fish

Sign: any indication of an animal's passage through or use of an area

Size: number of individuals in a population

Source population: an area where the main concentrated population of a species resides. Animals may disperse from this area to other locations

Specialist: a species that uses a narrow range of habitat components to meet its needs (i.e. may eat only one prey species)

Species of special concern: Colorado's designation for species that are at risk of becoming threatened or endangered

Subalpine forest: forests found in very high-mountain environments with elevations over 9,000 feet, just below tree line

Subpopulation: an identifiable portion of a larger population

Succession: the gradual change in a living community (i.e. aging of trees, replacement of one species with another)

Synchronous: an event happening at the same time in the same manner

Terrestrial: growing or living on land

Territories: areas animals defend against others of the same species

Threatened: species not in immediate peril of extinction, but vulnerable because they exist in small numbers or in such a limited range that they may become endangered

Transmitting system: a portion of the radio telemetry equipment that includes a radio transmitter, a battery, and an antenna all in one unit

Understory: the layer of shrubs, small trees, and other plants on the forest floor

U.S. Fish and Wildlife Service (USFWS): the federal wildlife agency that manages marine mammals, and migratory species, such as songbirds and waterfowl, because they cross state or national boundaries

Viable population: a population large enough to be self-sustaining

Wildlife management: the application of scientific knowledge and technical skills to protect, preserve, conserve, limit, enhance or extend the value of wildlife and its habitat

Notes