

Investi-gator



Fall 2013

A science journal for elementary school students

Animals and Ecosystems of the Southwestern United States



Investi-gator

Animals and Ecosystems of the Southwestern United States Edition

Number 3 • Fall 2013

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With thanks to

Project Learning Tree, <http://www.plt.org>

Produced by the Southwestern Region of the Forest Service (U.S. Department of Agriculture), the Rocky Mountain Research Station, Washington Office Forest Service Research and Development, Conservation Education, and the Cradle of Forestry in America Interpretive Association



Editorial Review Board

Comments from Pecos Elementary School, Pecos, New Mexico
Mr. Barela's 5th grade homeroom class with assistance by Mrs. Diana Grabowsky



The most important thing I learned is that riparian forests are excellent habitats for wildlife.

I loved reading about the people and some of the tables and charts, but they could be more detailed.



How did you guys come up with such a great story? I love those cute little hummingbirds!

Investi-gator is a good way to learn.



I learned that prairie dogs are important. So I am going to tell my family to try not to hurt prairie dogs.

I liked the pictures but they should be in color. It needs more color in the words.



Put more activities. Also put the animal's diet and their skeletal system.

The most important thing I learned was that animals are important and also scientists.



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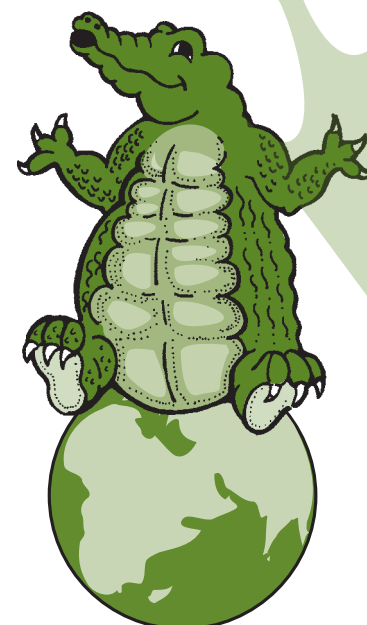
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Join Us in Being Green!

To reduce the amount of paper used to produce *Investi-gator*, the following sections are now available exclusively on the *Investi-gator* Web site, <http://www.scienceinvestigator.org>. These resources can be found with the Animals and Ecosystems in the Southwestern United States edition and on the "Educational Resources" pages:

- Note to Educators
- Lesson Plan
- Reflection Section Answer Guide
- Individual Article Education Standards Correlations

About *Investi-gator*

Investi-gator is the newest member of the *Natural Inquirer* family. *Natural Inquirer*, for middle school students, and *Investi-gator*, for upper elementary students, present science the way scientists most often share their research with each other. That process is the written scientific paper.

Each *Investi-gator* article presents research conducted by Forest Service scientists and their cooperators. All of the research in *Investi-gator* is concerned with nature or with society's relationship to nature.



Each article is organized the same way and includes the following sections:

Meet the Scientist

An introduction to the scientist or scientists who conducted the research.

Thinking About Science

A short introduction to something about the scientific process that is related to the research being presented.

Thinking About the Environment

A short introduction to something about the natural environment that is related to the research being presented.

Introduction

The part of the written scientific paper that introduces the scientific problem or question the scientists wanted to solve or answer.

Methods

The part of the written scientific paper that describes how the scientists collected and analyzed their data or information.

Findings

The part of the written scientific paper that describes what the scientists discovered.

Discussion

The part of the written scientific paper that summarizes the research and offers any new insights.

Reflection Sections

These are questions placed behind the Introduction, Methods, Findings, and Discussion sections. The purpose of the questions is to help students think about what they have read.

Glossary

Possible new terms found in the article. Glossary words are printed in bold in the article.

FACTivity

This is an activity that you can do in your classroom.





Who Are Scientists?



Scientists are people who collect and evaluate information about a wide range of topics. Some scientists study the natural environment.

To be a successful scientist, you must:

- ✓ **Be curious:**
Are you interested in learning?
- ✓ **Be enthusiastic:**
Are you excited about a particular topic?
- ✓ **Be careful:**
Are you careful in everything that you do?
- ✓ **Be open-minded:**
Are you willing to listen to new ideas?
- ✓ **Question everything:**
Do you think about what you read and observe?



Welcome to the Animals and Ecosystems of the Southwestern United States Edition of *Investi-gator*!

When most people think of the Southwestern United States, they think about deserts, deep canyons, cacti, and hot temperatures (**figure 1**). All those things help describe the Southwest. It is important to know, however, that the Southwest also has high **mesas**, mountains, trees, and cold temperatures. Some areas of these states even get snow, especially in the mountains. It is possible to play in the snow in the mountains and swim in an outdoor pool in a valley in the same day!



Figure 1. Many people think of cacti when they think of the Southwestern United States. Photo courtesy of the Forest Service Rocky Mountain Research Station Pathology Archive and <http://bugwood.org>.

The research in this journal was done in the Southwestern United States. The Forest Service identifies the Southwest as including the states of Arizona, New Mexico, and the western parts of Oklahoma and Texas (**figure 2**).

Glossary words are in **bold** and defined on page 9.

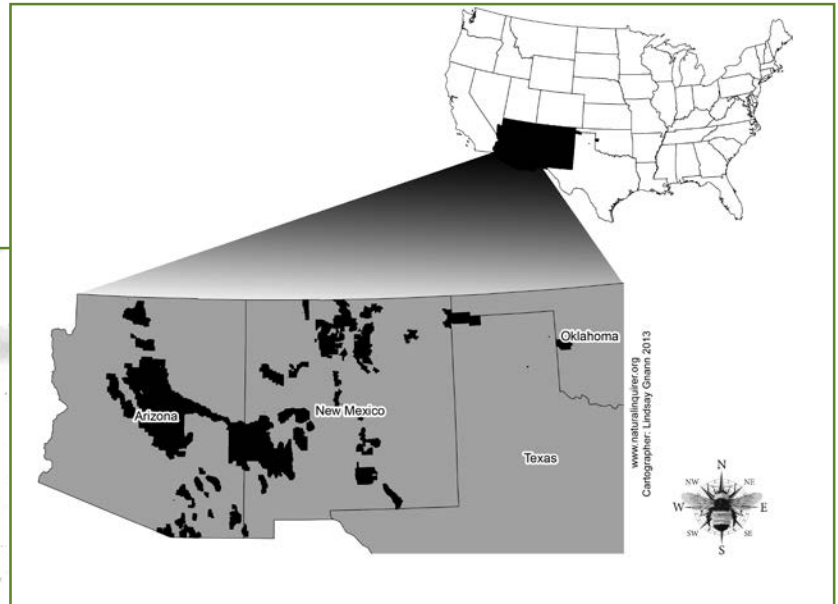


Figure 2. The Forest Service identifies the Southwest as including the states of Arizona, New Mexico, and western parts of Oklahoma and Texas. The dark areas show the location of national forests.

The Southwest is an **arid** land with lots of sunshine, low **humidity**, and occasional high winds. These factors affect the way people live their lives there. Water is **scarce**. Sometimes people are only allowed to water their yards on certain days. Some people put small, decorative rocks in their yard instead of having grass that needs to be watered (**figure 3**). Little moisture and high winds are found in the forests and grasslands, so large **wildfires** are common (**figure 4**). These large wildfires change how the land looks. Wildfires also affect what kind of animals and plants live in an area.



Figure 3. It is common to see decorative rocks in front yards of the Southwestern United States. Photo courtesy of Jean Szymanski.



Figure 5. Some early Southwestern peoples built and lived in cliff dwellings. Photo by Michelle Andrews.



Figure 4. Wildfires are common in the Southwestern United States. Photo courtesy of Kari Greer Photography, <http://www.kariphotos.com>.



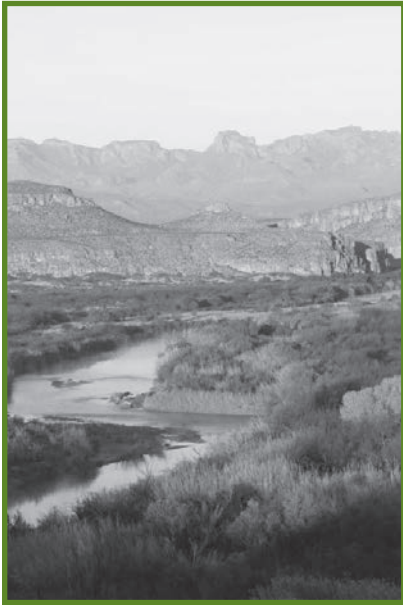
Figure 6. Apache woman and papoose on the San Carlos Reservation in 1926.

Photo by Stone and courtesy of the National Park Service Historic Photo Archive.

Southwestern people have lived close to the land for centuries. More **archaeological** sites are found in the Southwest than anywhere else in America (**figure 5**). The area was settled by Spanish, Mexican, Native American, and **Anglo-American** people. Each of these groups of people lived on and used the land differently (**figure 6**).

In this journal, you will learn many interesting facts about the Southwestern United States. In “That’s a Humdinger!” you will discover what happens to hummingbird nesting

following different kinds of forest-related treatments. In “By the Light of the Silvery Minnow,” you will find out whether a small minnow can learn to find natural foods. Without success, this minnow **population** might one day disappear. You will learn how climate change might affect 30 different animal **species** in the article entitled, “Wild Ways.” Some of these species are already in danger of **extinction**.



The Southwestern United States is a dry region. In “Streaming Live,” you will discover how well trees living in the Southwest use available water resources. “Prairie Dog Days” will introduce you to interesting facts about prairie dogs. You will learn how a small insect is causing big problems for a species of prairie dog. Finally, in “The Lands of Time,” you will find out how some people in New Mexico feel about land their **ancestors** owned in the past.

The Southwestern United States is a special place. This *Investi-gator* will introduce you to a lot of fun facts about the animals, plants, and people living in the American Southwest.

Photos courtesy
of the U.S. Forest
Service.



Glossary

Anglo American (aŋ glō ə mer ə kən): A white American citizen of non-Hispanic descent.

archaeological (är kē ä lə jə kəl): Having to do with the scientific study of material remains of past human life and activities.

arid (a rəd): Excessively dry.

extinction (ik stiŋ(k) shən): The state or situation that results when something (such as a plant or animal species) has died out completely.

humidity (hyü mī də tē): The amount of moisture in the air.

mesa (mā sə): A flat-topped hill with steep sides.

population (pä pyə lā shən): A group of one or more species of organisms living in a particular area or habitat.

scarce (skers): Not plentiful.

species (spē shēz): A class of individuals having common attributes and designated by a common name.

wildfire (wī(-ə)ld fī(-ə)r): An uncontrolled fire that destroys a large area.

Accented syllables are in **bold**. Marks and definitions are from <http://www.merriam-webster.com>.

That's a Humdinger!

Black-Chinned Hummingbird Nesting in Response to Forest Treatments

Photo by Larry Thompson.



Meet the Scientists!



Mr. Max Smith, wildlife biologist: My favorite science experience is going outside to discover where birds nest, what they eat, and what eats them. In the photo, I am bird-watching with my dog near Seattle, Washington.



Dr. Deborah Finch, biologist: My favorite science experience is monitoring bird nests. I especially enjoy watching the adult birds build nests in trees and shrubs. I also like observing the nestlings grow and finally pop out from the nests and flutter to the ground.

What Kind of Scientist Did This Research?

biologist: This scientist studies living organisms and living systems.

wildlife biologist: This scientist studies animals living in the wild, including what they eat, their habitat, and how they interact with their environment.

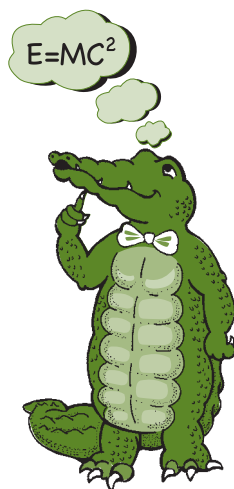


Thinking about Science

Observation is an important skill for a scientist. Observation is the ability to watch something closely to gain information and details. In this study, the scientists frequently used their observation skills. The scientists observed hummingbirds and their nests over a 7-year period.

Sometimes it was difficult for the scientists to see the whole nest. When the scientists could not see the nest, they made other observations to tell if the nest was doing well. For example, the scientists watched to see if birds were coming and going. The scientists also had several different people observe the nests to gather more data.

The data the scientists gathered from these observations helped them to better understand hummingbirds and their nesting behavior. The next time you are outside, take 5 minutes to observe your surroundings. Write down



three things that you noticed while you were observing that you never noticed before. Share your observations with your classmates.

Thinking About the Environment

Riparian (rə per ē ən) forests are found along streams, rivers, and other waterways (**figure 1**). These forests are a **transition** area between water and upland areas (**figure 2**). Riparian forests are important because they help with flood control, water quality, and wildlife **habitat**.

Forests help with flood control because a forest is like a sponge. Forests store water during floods just like a sponge stores water when you are washing dishes. Forests also help stop **erosion** along the banks of a river. The roots of trees and other plants help hold soil in place. These roots also help improve water quality by keeping extra soil, **sediment**, and pollution from getting into the water.



Figure 1. A riparian forest is **productive** because it is close to water. High soil quality in a riparian forest also makes the forest productive. Photo courtesy of Gila National Forest.



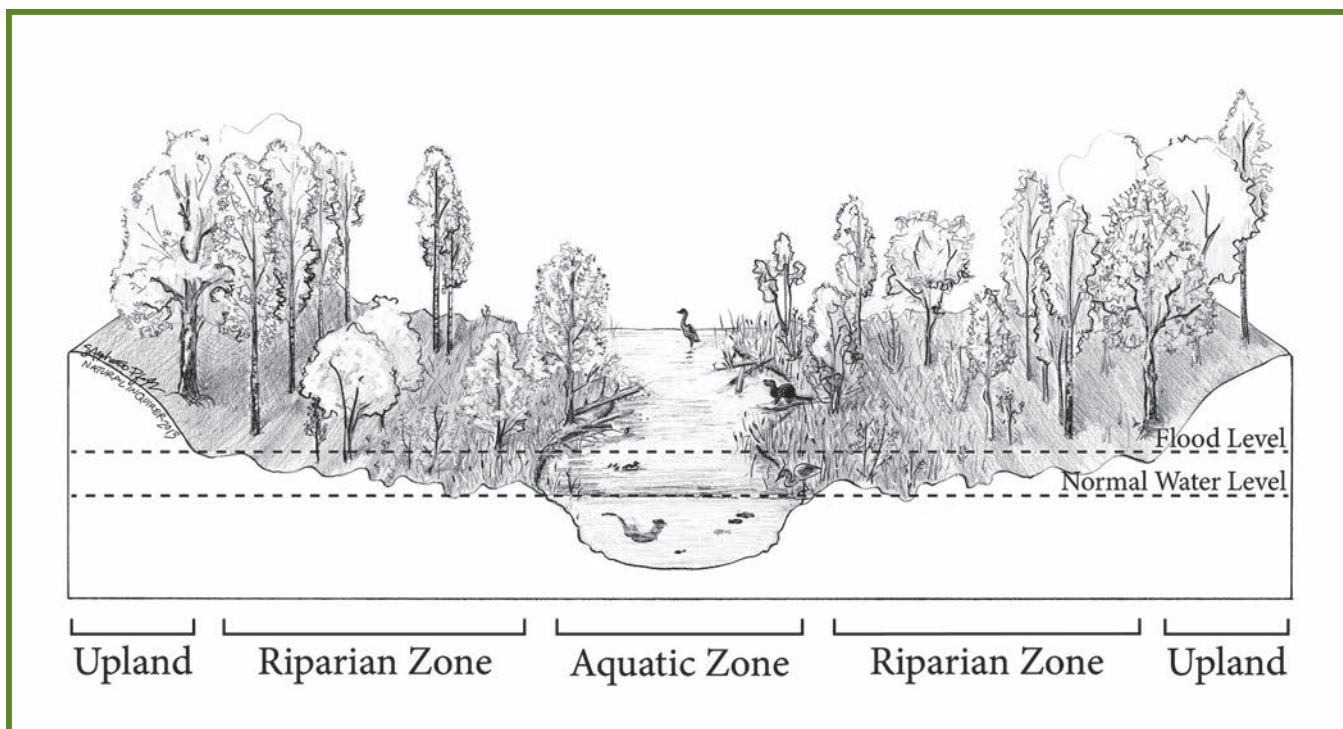


Figure 2. The plants found in riparian areas often have characteristics of both the aquatic ecosystem and the upland areas because they are in this transition zone. Aquatic means that something is growing or living in or upon water.

Illustration by Stephanie Pfeiffer.

Riparian forests are also excellent habitats for wildlife. Forests provide food and shelter for many animals. These forests, for example, help shade waterways. The shade keeps the water cool and improves the aquatic habitat for certain animals. Trees and shrubs in the forests are also used as habitats by a variety of land animals. The scientists in this study were interested in the black-chinned hummingbird that makes its home in riparian forests (**figure 3**).



Figure 3. A black-chinned hummingbird and its nest.

Photo courtesy of Thinkstock.com.

Introduction

Many different types of birds live in riparian forests. In this study, the scientists were interested in black-chinned hummingbirds that live in riparian forests (**figure 4**). The scientists wanted to know if black-chinned hummingbirds were being affected by human changes to the forest.



Figure 4. The black-chinned hummingbird has a purple band on its neck. This is a male hummingbird. To see this photo in color, visit <http://www.scienceinvestigator.org>. Photo courtesy of Deborah Finch.



Did You Know?

All hummingbirds, including black-chinned hummingbirds, lay only two eggs at a time. Look at figure 3. How many baby hummingbirds do you see? Black-chinned hummingbird eggs are about the size of a coffee bean. The adults create nests that expand as the nestlings grow because the birds make their nests using spider silk and cocoon fiber. To find out more about black-chinned hummingbirds, visit http://www.allaboutbirds.org/guide/black-chinned_hummingbird/lifehistory.

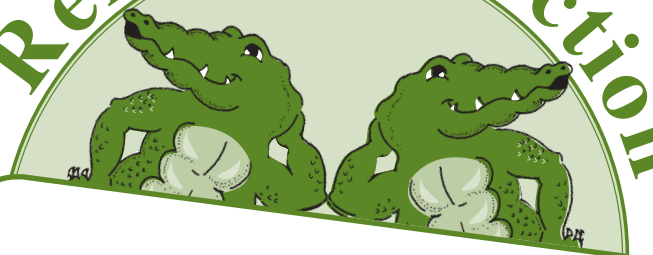
Number Crunch

Get 10 whole coffee beans. Measure and record the length of each bean. Calculate the average length of the 10 coffee beans. What would you say, on average, is the length of a black-chinned hummingbird egg?

Humans make changes to forests for a variety of different reasons. These changes are called forest management. Sometimes forests are managed to reduce the risk of **wildfire**. When forests are managed to reduce the risk of wildfire, several treatments may be done. One of the treatments to reduce the risk of wildfire is to remove small trees and shrubs. Extra **litter** and **debris** may also be removed. The scientists in this study examined this management method to see if it had an effect on hummingbirds.

Forests are also managed to reduce the amount of **invasive** species. Invasive species include plants, animals, or organisms that are not **native** to where they live. Invasive species may cause harm to the environment, the **economy**, or human health. In this study, the scientists used **herbicides** to get rid of the invasive plants in the forest. The scientists also studied this method of management to see if it had an effect on hummingbirds.

Reflection Section



➔ What did the scientists want to find out in this study?

➔ Why do you think removing small trees, shrubs, and extra litter may help reduce the risk of wildfire?



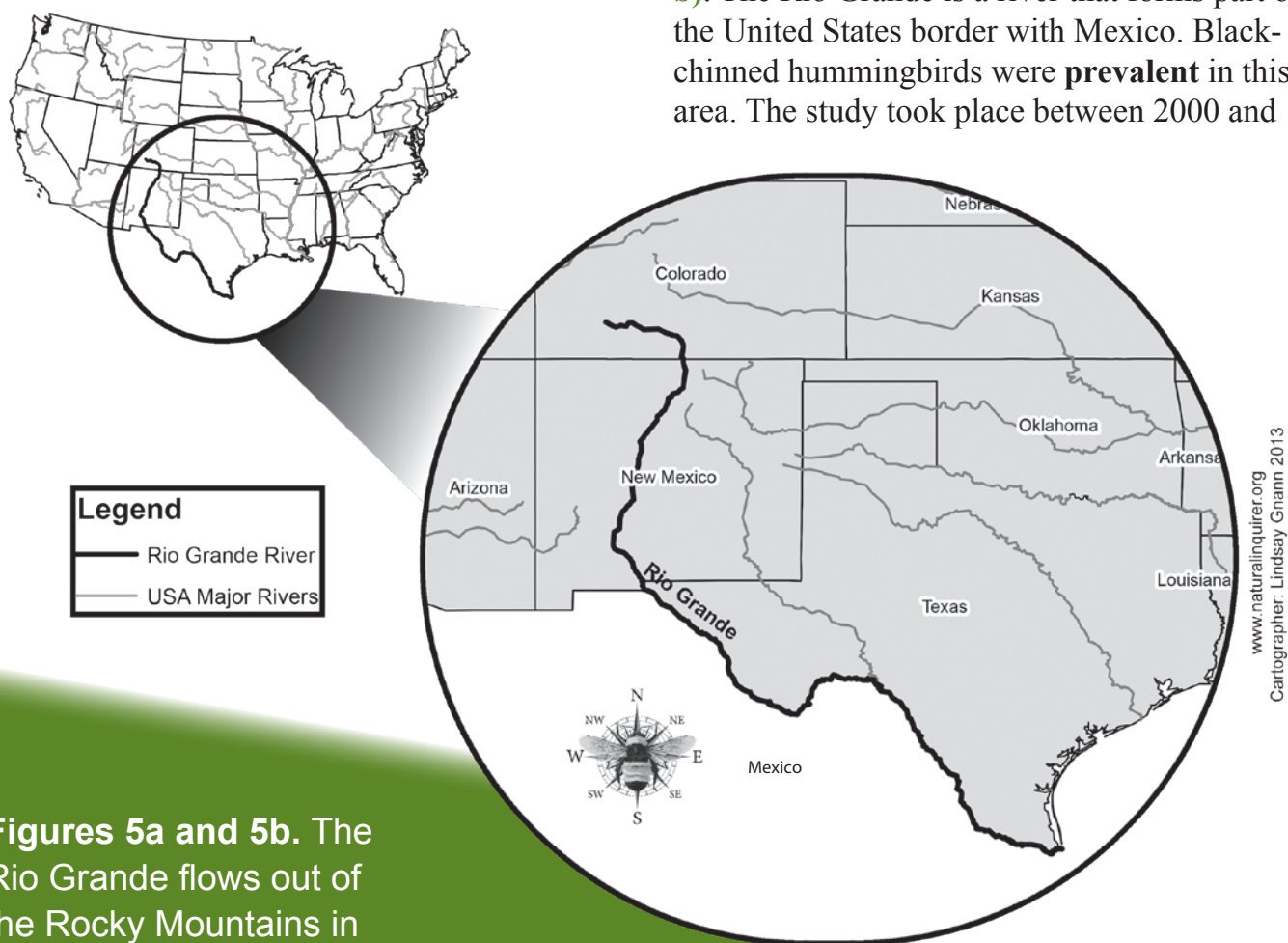
Photo courtesy of Gila National Forest.

Methods

The scientists wanted to figure out if forest management methods affected black-chinned hummingbird nesting. To figure this out, the scientists examined three things. First, they looked at where in the forests the hummingbirds nested. This included identifying what species

of trees and how high off of the ground the birds nested. The scientists studied how these areas changed following treatment. Then, the scientists looked at whether the nests survived.

The scientists did their study in central New Mexico along the Rio Grande (figures 5a and b). The Rio Grande is a river that forms part of the United States border with Mexico. Black-chinned hummingbirds were **prevalent** in this area. The study took place between 2000 and



Figures 5a and 5b. The Rio Grande flows out of the Rocky Mountains in Colorado to the Gulf of Mexico.

Photo by Chuck Murphy and <http://www.boywithcamera.com>.



2007. The scientists identified three land areas that they called blocks along the northern, middle, and southern **reaches** of the Rio Grande.

Each block was divided into four plots (**figure 6**). In each set of four plots, one plot was **randomly** selected as a **control** plot. The control plots were areas that the scientists did not treat. The scientists compared the control plot to the other plots. This comparison enabled the scientists to learn whether the treatments or something else were affecting hummingbird nests. The other three plots were treated in three different ways.

In one plot, invasive shrubs and woody debris were cut down and chipped. Herbicide was then applied twice to the remaining roots of the invasive shrubs. In the second plot, the scientists repeated the first treatment. Then they planted native shrubs in the areas where they cut down the invasive shrubs. In the third plot, the invasive shrubs were cut, piled, and burned. Afterwards, herbicide was twice applied to the remaining roots of the plants that had been cut (**figure 7**).

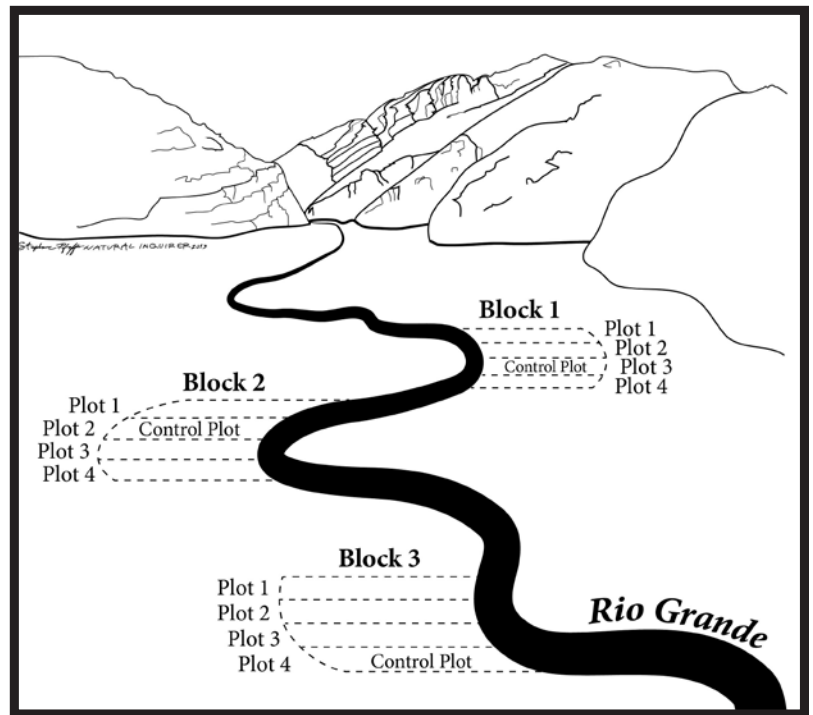


Figure 6. Each block was divided into four plots. Illustration by Stephanie Pfeiffer.

No Treatment. (control plot)	Invasive shrubs cut & chipped. Herbicide applied twice to roots.
Invasive shrubs cut & chipped. Herbicide applied twice to roots. Native shrubs planted.	Invasive shrubs cut, piled, and burned. Herbicide applied twice to roots.

Figure 7. The four treatments applied in the plots.

Number Crunch
If each of the three blocks were divided into four plots, how many total plots were established?

What is chipping?

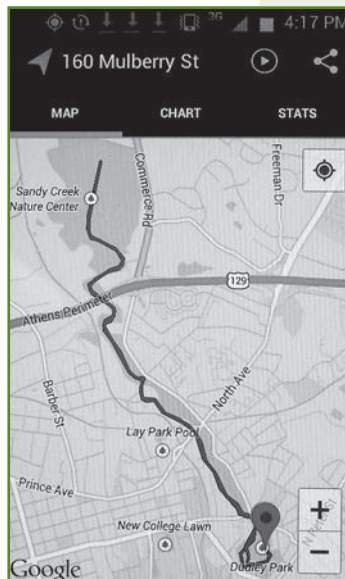
Big machines are used to turn trees and shrubs into small chips (**figure 8**). These chips are often used as a ground cover or are placed around trees to help hold moisture in the ground.



Figure 8. Large chipping machines turn large trees into small chips of wood. Photo courtesy of the U.S. Forest Service.

The scientists **monitored** all plots for the presence of black-chinned hummingbird nests and birds. The scientists monitored the areas between the beginning of May and the end of August each year. The location of each nest was recorded with a Global Positioning System (GPS) unit. The scientists also measured the height of the nest from ground level. They visited each nest every 3 to 5 days to make observations until nesting was complete. When possible, the scientists looked into the nests to see if the two eggs, and later the two tiny nestlings, were still in the nest. Nestlings are young birds that have not yet left the nest.

Once the nesting was complete, the scientists did two things. The scientists first measured and recorded the height of the tree or shrub. Then the scientists identified and recorded the condition (alive or dead) of the tree or shrub in which the nest was located.



What is GPS?

A GPS is a navigation system. GPS stands for Global Positioning System. A GPS can tell the exact **coordinates** of where you are located on Earth. A GPS works by using satellites orbiting Earth to send information to GPS receivers. At any time, at least three satellites are able to send signals to any receiver on Earth. GPS was designed in 1973 by the United States military. The military designed GPS to help soldiers and military vehicles find their exact location anywhere in the world. Today, GPS units are used in a wide variety of ways. Often, cell phones have GPS receivers and you may even have a GPS device in your car that tells you directions!

Reflection Section

Why do you think the scientists monitored hummingbird nesting sometime between the beginning of May and the end of August every year?

Why do you think the scientists visited the nests every 3 to 5 days until nesting was complete?

Photo by Chuck Murphy and
<http://www.boywithcamera.com>.



Female ruby-throated hummingbird.

Findings

The scientists found that black-chinned hummingbirds chose their nest areas differently in different plots. The hummingbirds made more nests in the cottonwood **canopy** after the area had been treated (**figure 9**). The nest location was also higher after an area had been treated.

From 2000 to 2007, the scientists observed 635 hummingbird nests. A majority of the nests (61 percent) survived. Of the 237 nests that did not survive, the cause of failure was not always clear. Some nests may have failed because of predators, weather, starvation, or fire. The scientists found, however, that nest survival rates were lower after treatments.

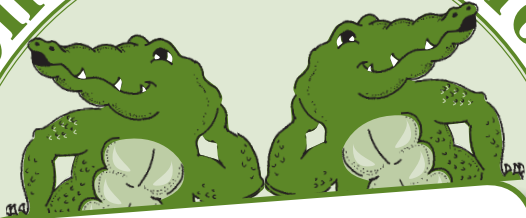


Figure 9. The cottonwood canopy provided a nesting area for hummingbirds after treatments. This cottonwood canopy is located in New Mexico. Photo by Rod Replogle, Forest Service.

Number Crunch

What percentage of the hummingbird nests represents a majority? Write the percentage in decimal form.

Reflection Section



Why do you think it may have been hard to figure out why a nest failed?

In your own words, summarize the major findings from the study.

Discussion

Before treatment, the riparian forest had a thick **understory** below a cottonwood canopy (**figure 10**). After treatment, the area looked like open woodlands with very few shrubs (**figure 11**). In response to these treatments, the hummingbirds moved their nesting areas to the cottonwood canopy.

The scientists think that hummingbird nests located high in cottonwood trees are at greater risk from predators. The scientists think that the nests are easier for predators to see in the canopy as compared to nests that are located lower in thick shrubs and plants. Compare figures 9 and 10 to see if you agree with the scientists.

The scientists also found evidence that nest survival was greater in the understory. Scientists suggest that after treatments, it is important to plant native shrubs and saplings so the hummingbirds have safer places to nest. Recall that one of the treatments included planting native shrubs. The scientists think that these shrubs did not have a chance to get large and **dense** enough to provide protection.

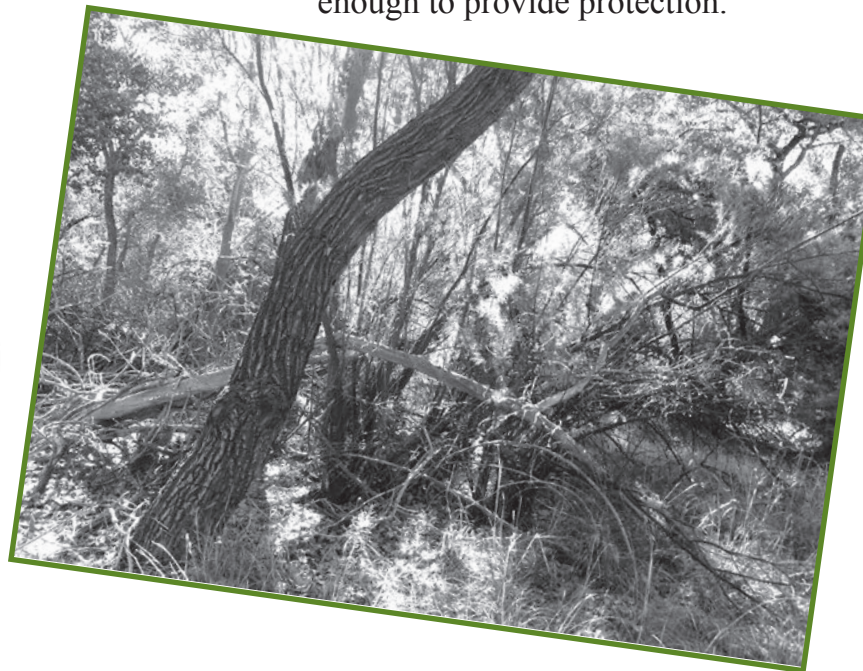


Figure 10. The understory is the area close to the ground underneath the tall trees. The understory is made up of small trees, shrubs, and other plants. Photo by Max Smith.

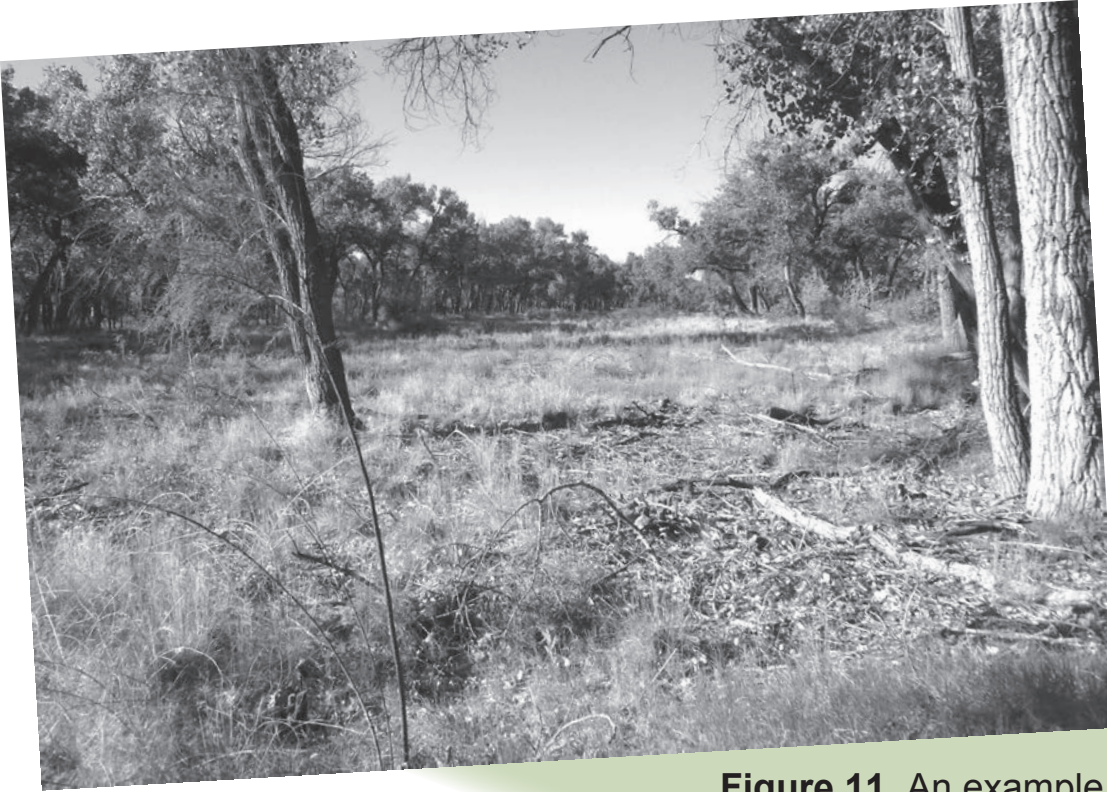
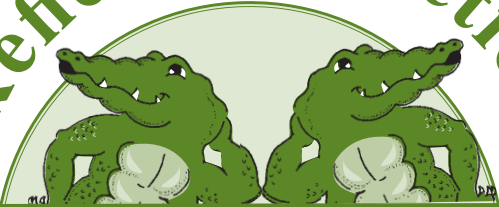


Figure 11. An example of how the area looked after treatment.
Photo by Max Smith.

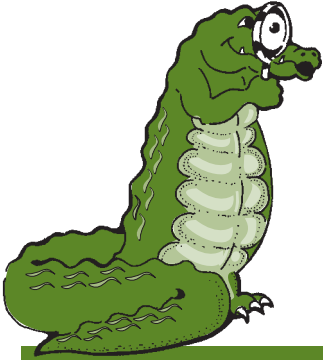
Reflection Section



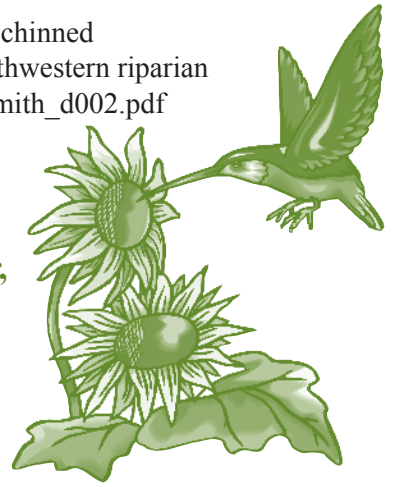
➡ Why do you think hummingbird nests may be safer in thick shrubs and plants?

➡ Forest managers are often faced with decisions about how to best manage an area for multiple concerns. In this study, the area needed to be managed for fire, invasive species, and habitat for hummingbirds. Think of a time when you had to make a decision and there were competing interests. For example, you received \$10 from your grandmother and you really wanted to buy a video game with it, but you also wanted to buy a present for your mom's birthday. Think about how you made your decision. Write down two sentences about how you made your decision and compare it to the decisions these forest managers must make. Discuss with your class.

Adapted from Smith, D. Max; Finch, Deborah M.; Hawksworth, David L. 2009. Black-chinned hummingbird nest-site selection and nest survival in response to fuel reduction in a southwestern riparian forest. *The Condor*. 111(4): 641-652. http://www.fs.fed.us/rm/pubs_other/rmrs_2009_smith_d002.pdf



If you are a trained Project Learning Tree educator, you may use Activity 12: Invasive Species or Activity 22: Trees as Habitat.



Glossary

aquatic (ə kwä tik): Growing or living in or often found in water.

canopy (ka nə pē): The uppermost spreading branchy layer of a forest.

control (kən trōl): Part of an experiment that is not treated with something being tested. It serves as a comparison in the experiment.

coordinate (kō ōrd nət): Any of a set of numbers used to locate a point on a line or surface or in space.

debris (də brē): The remains of something broken down or destroyed.

economy (ē kā nə mē): A system relating to the production, distribution, and consumption of goods and services.

ecosystem (ē kō sis təm): Community of plants and animal species interacting with one another and with the nonliving environment.

erosion (i rō zhən): The process or state of wearing or washing away.

habitat (ha bə tat): The environment where a plant or animal naturally grows and lives.

herbicide ((h)ər bə sīd): Chemical substance used to destroy or stop plant growth.

invasive (in vā siv): Tending to spread or infringe upon.

litter (li tər): The uppermost slightly decayed layer of organic matter on the forest floor.

native (nā tiv): Living or growing naturally in a particular region.

prevalent (pre və lənt): Widespread.

productive (prə dāk tiv): Having the quality or power of producing especially in abundance.

randomly (ran dəm lē): Selecting in such a way that each has an equal chance of being selected.

riparian (rə per ē ən): Areas along streams and rivers.

sediment (se də mənt): Material deposited by wind, water, or glacier.

transition (tran zi shən): A changing from one state, stage, place, or subject to another.

understory (ən dər stōr ē): The layer of plants and especially the trees and shrubs between the forest canopy and the ground cover.

Accented syllables are in **bold**. Marks and definitions are from <http://www.merriam-webster.com>.

The title “That’s a Humdinger!” is a phrase that refers to a striking or extraordinary person or thing. In this case, the extraordinary thing is the hummingbird. Learn more about hummingbirds at <http://www.dgif.virginia.gov/habitat/hummingbirds.asp>.



FACTivity

Time needed: Two class periods.
The first day will be a classroom activity. The second day will be a classroom or field exercise.

The question
you will answer in this
FACTivity is:

What species of birds
are found living in my
schoolyard?

Materials

- “That’s a Humdinger” article
- Copies of “Bird Identification Chart” on page 26
- Bird field guides (online editions or printed copies)

• Pencils

Optional: binoculars, digital camera



As you learned in the “That’s a Humdinger!” article, a riparian forest is an area of forest between water and upland areas. Riparian forests provide habitat for wildlife, including many species of birds. Schoolyards can also provide habitat for wildlife. If your schoolyard has trees, it is an urban forest, a special type of forest. Urban forests are found throughout cities and other developed areas. Urban forests may have just a few trees, or they may have many trees.

The scientists in the “That’s a Humdinger!” article studied black-chinned hummingbirds in New Mexico. They wanted to see if the birds’ nests were affected by forest management activities. The scientists observed the birds and their nests, and watched their behavior. Like the scientists, you will conduct a study to observe birds found in your schoolyard.

Birds are important to ecosystems. They help control insect populations. Birds help scatter plant, tree, and flower seeds. Birds are prey for predators, and they serve an important role in the food web. Many people also enjoy birding, or bird-watching. Scientists who study birds are called ornithologists (**or nə thă lə jists**). In this FACTivity, you will act as an ornithologist while learning to identify birds seen in your schoolyard.

For more information about urban forests, see the *Natural Inquirer* Urban Forest Edition at <http://www.naturalinquirer.org>.



Day One: Learn to Identify Birds

1. If you haven't previously done so, read the "That's a Humdinger!" article.
2. Make a list of birds that you think you might see in your schoolyard. If you live close to the school, it's likely that you will see the same bird species at school that you see around your home.

For each bird that you list, explain how you know what bird it is. For example, tell if it has red feathers or a thick beak. You might want to use a bird identification guide to give you some ideas.

3. Next, your teacher will divide you into small groups. Each group will be given a field guide. You may also use online resources such as Cornell University's "All About Birds" Web site (<http://allaboutbirds.org>). The "Bird ID" section of the "All About Birds" Web site provides images and text that cover bird identification clues in detail.

In your group, study the field guide and become familiar with ways to identify birds in the field. View images of birds that are common to your local area. This can be done by:

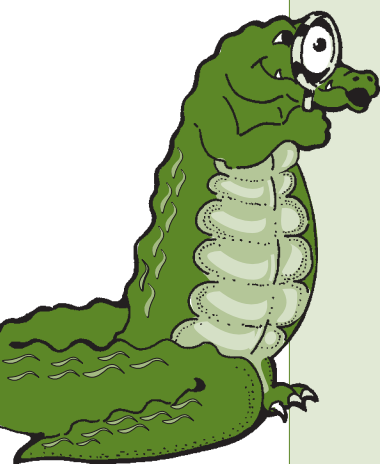
- Using BirdSleuth focus cards (order at <http://www.birds.cornell.edu/birdsleuth>).
- Viewing an online bird guide (<http://www.allaboutbirds.org> or <http://www.enature.com>).
- Looking at pictures of local birds (taken from magazines, posters, or the Internet) or looking at pictures in a field guide or textbook.



Photo courtesy U.S. Fish and Wildlife Service.



Day Two: Observe and Identify Birds in Your Schoolyard



1. You will observe birds seen at your school. Birds can be observed by looking out the classroom window or by going outside with your teacher. Your teacher will pass out the Bird Identification Chart to each student. If you have binoculars, they can be used to help you see birds close-up.
2. In your small group, discuss the Bird Identification Chart with your classmates. Work together to discuss identification features and ways to identify birds. Use the completed chart to help you fill out the Bird Identification Chart for one species of bird that you observe. Write down key identification features of a bird you see, such as "This bird has blue feathers and sits upright on a branch."
3. Work with your small group using field guides to determine if your identification is correct.
4. As a class, discuss the birds you observed and the features used to identify them.
5. Once you have practiced observing birds from your classroom, go outside with the class (if you haven't already) and observe birds in the schoolyard. Practice using a field guide to identify birds that you see.



Photo by Chuck Murphy and <http://www.boywithcamera.com>.

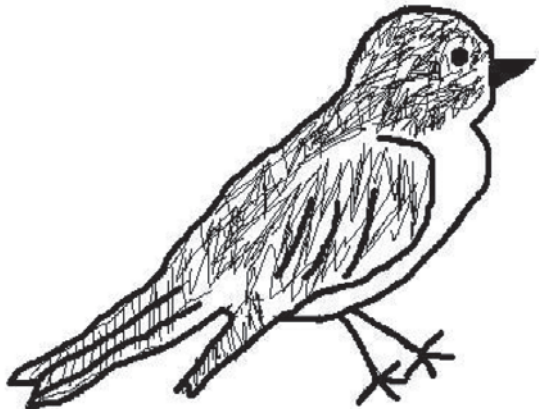
Photo courtesy of Gila National Forest.



FACTivity Extension:

Now that you've practiced observing birds, your class can conduct a Stationary Bird Count and submit the data online to the BirdSleuth database. For more information and instructions on how to complete this extension, view the "Birding FACTivity" on the *Natural Inquirer* Web site at <http://www.naturalinquirer.org/Outdoor-v-102.html>.

Sample Bird Identification Chart

Name: Eastern Phoebe	Size: About the same size as a sparrow, about 7" from head to tail.
Sketch 	Shape: Plump bird with medium-long tail. Short, thin, black beak.
	Field Marks: Dark head that fades to lighter color on back. White throat.
	Behavior(s): Flew from perch to catch an insect in the air. Bobbed up and down and from side to side when sitting on a branch.
	Song(s) or call(s): Raspy "fee-bee" call and some soft chirps.
Color(s): Dark brownish-gray above, off-white below. Light patch of yellow on belly.	Habitats/Other comments: Perched on low branches; did not seem scared of humans.

This activity was adapted with permission from the Cornell Lab of Ornithology's BirdSleuth curriculum. To order the complete curriculum set, visit <http://www.birds.cornell.edu/birdsleuth/>.

Bird Identification Chart

Name:	Size:
Sketch	Shape:
	Field Marks:
	Behavior(s):
	Song(s) or call(s):
Color(s):	Habitats/Other comments:

Additional Web Resources

Cornell Lab of Ornithology- Black-chinned hummingbird
http://www.allaboutbirds.org/guide/Black-chinned_Hummingbird/id

Audubon Kids Page
<http://www.audubon.org/educate/kids/>

Tucson Bird and Wildlife Festival
<http://www.tucsonaudubon.org/festival.html>

Attracting Hummingbirds
<http://www.hummingbirds.net/attract.html>

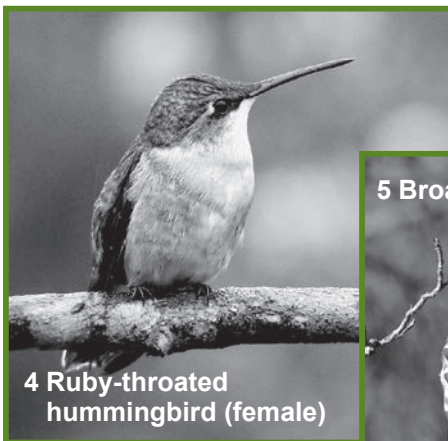
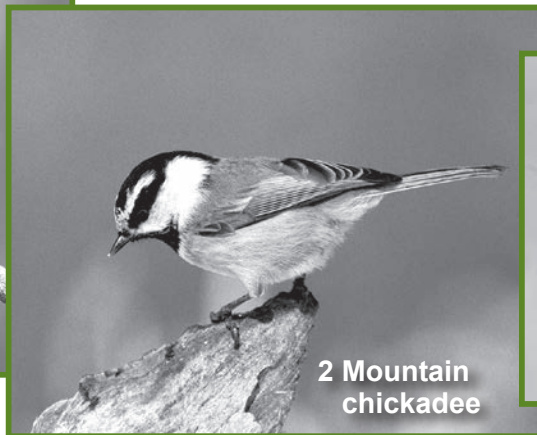


Photo Credits:
1, 3 and 4: Chuck Murphy and
<http://www.boywithcamera.com>.
2: Photo by Dave Menke and courtesy of
U.S. Fish and Wildlife Service.
5-7: James Holland.

By the Light of the Silvery Minnow

Can Young Minnows Be Taught About Their Natural Foods?

Meet the Scientist!



Dr. Hugo Magaña, fisheries biologist

My favorite science experiences are teaching about photosynthesis and studying food webs. In this photo, I was collecting algae from which I would later create pure diatom cultures. Diatoms are one-celled algae. I then created diatom pucks from those cultures. You will learn about diatoms and diatom pucks in this article!

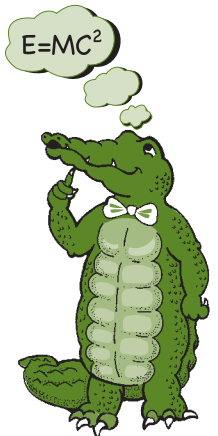
What Kind of Scientist Did This Research?

fisheries biologist: This scientist studies fish living in the wild, including what they eat, their **habitat**, and how they interact with their environment.

Thinking About Science

Of all the talents needed by scientists, one of the most surprising is creativity. To solve problems and answer questions, scientists need to think in new ways. Albert Einstein once said, “I am enough the artist to draw freely upon my imagination. Imagination is more important than knowledge.” Einstein meant that to discover new things, we must use our imagination and our creativity.

In this research, you will read about a creative way to study fish. The scientist in this study used his imagination and technology to learn something new about a small minnow that lives in the Rio Grande. The Rio Grande is a river in the Southwestern United States.



Thinking About the Environment

The Rio Grande is a long river. The Rio Grande's **headwaters** are in Colorado. The river runs through Colorado and New Mexico. The river leaves New Mexico and forms part of the United States boundary with Mexico in Texas (**figure 1**). In the past, the Rio Grande was a wide, shallow, **meandering** river (**figure 2**). In the 1940s, people began to change the river. They created dams to control floods (**figure 3**). People also dug channels to **divert** water from the river to their agricultural fields. The Rio Grande is different today than it was before the 1940s.

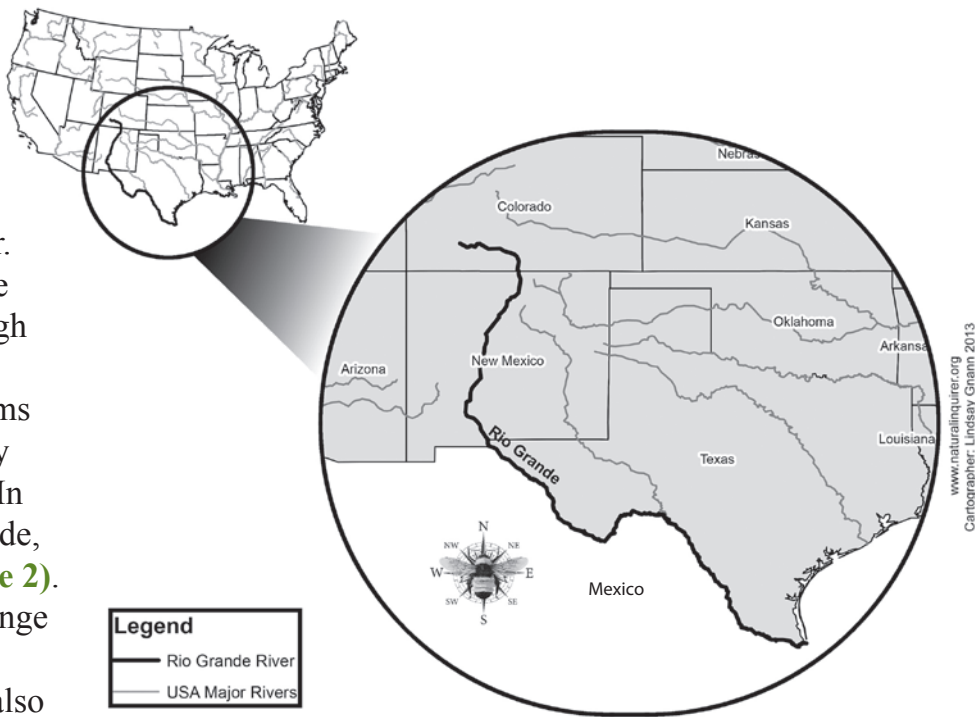


Figure 1. The Rio Grande flows from Colorado and eventually forms part of the United States boundary with Mexico.



Figure 2. Before the 1940s, the Rio Grande was a wide, shallow river with many bends. Photo by Chuck Murphy.



Figure 3. Dams were built on the Rio Grande to control floods. This is the Elephant Butte dam. Photo courtesy of the United States Bureau of Reclamation.



Because of the changes made to the Rio Grande since the 1940s, the river now provides a lower quality habitat for some fish and other **aquatic** animals. Some of the fish that thrived before the 1940s are not doing as well in the changed Rio Grande. One of these fish is the Rio Grande silvery minnow (*Hybognathus amarus*) (**figure 4**).

In the past, the silvery minnow was the most **abundant** fish in the river. Now, the silvery minnow is listed as **endangered** by the U.S. Fish and Wildlife Service. When a species is listed as endangered, it means its population may disappear in all or in many of the areas where it lives.

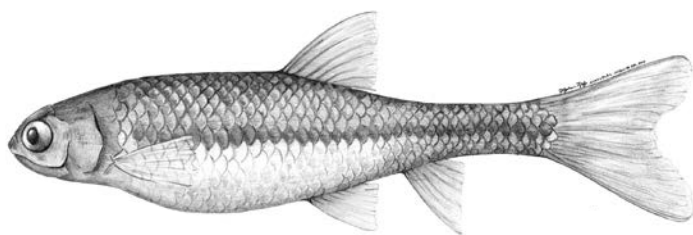


Figure 4. The Rio Grande silvery minnow is a small fish. An adult may reach 3.5 inches, or 8.89 centimeters. Is this illustration of the silvery minnow life-sized? How do you know? Illustration by Stephanie Pfeiffer.

Introduction

Many changes have occurred in the Rio Grande since the 1940s. (See “Thinking About the Environment.”) These changes created a river that is deeper and faster. This different habitat has created problems for the Rio Grande silvery minnow **population**. So few silvery minnows now live in the Rio Grande, the fish is in danger of becoming **extinct**.

WHERE DO SILVERY MINNOWS LIVE AND WHAT DO THEY EAT?

Silvery minnows prefer slow-moving water. These minnows are found in **eddies**. These eddies are formed by **debris** in the water and in shallow pools. In the summer, silvery minnows stay in shallow water that is less than 20 centimeters (7.9 inches) deep. In the winter, the minnows stay in water between 31 and 40 centimeters (12.2-15.75 inches) deep. Silvery minnows prefer to swim near the river bottom. The minnows prefer to swim there because they feed near the river bottom. Silvery minnows are covered with taste buds all along their underside, head, and mouth. These taste buds allow silvery minnows to detect food even when they cannot see in slow-moving, **turbid** water. Look at the photo of Dr. Magaña on page 28. He is standing in turbid water.

When water flow is slow, algae are the preferred food of the Rio Grande silvery minnow. Algae are aquatic plants that create their own food. Silvery minnows eat aquatic invertebrates during floods when the water is flowing quickly. Aquatic invertebrates are small animals, such as insects, crustaceans, mollusks, and worms, that live in water. Invertebrates do not have a backbone (**figure 5**).



Figure 5. Invertebrates are animals without a backbone. Are humans invertebrates? How do you know? Is the silvery minnow an invertebrate? Illustration by Stephanie Pfeiffer.

Number Crunch

Before the 1940s, silvery minnows could be found in 3,862 kilometers (2,400 miles) of the Rio Grande. Today, silvery minnows are found in 280 kilometers (174 miles) of the Rio Grande. Write the distance today compared with the distance in the 1940s as a fraction.

Extension: In what percentage of their past habitat are silvery minnows found today?

To rebuild the population of Rio Grande silvery minnows, biologists raise the minnows in fish **hatcheries** (figures 6a and 6b). Biologists feed the minnows in the hatcheries with food that is made in factories (figure 7). This food is unlike the minnows' natural food. When the minnows are released into the Rio Grande, 95 percent of them starve or are eaten by other animals. Some scientists believe that the minnows starve because they do not recognize their natural food sources.



Figure 6a. Rainbow trout raised in a North Carolina fish hatchery. Photo by Babs McDonald.



Figure 6b. Fish hatcheries do not provide a natural environment for young fish. Photo by Babs McDonald.



Figure 7. Emily Melear-Daniels feeds fish in a North Carolina fish hatchery. When fish are released into streams, they have to find their own food.

Photo by Babs McDonald.

The scientist in this study was interested in the natural diet of silvery minnows. Silvery minnows are mostly plant-eaters. Young silvery minnows eat algae. The type of algae they feed on is made up of diatoms.

What are diatoms?

Diatoms are one-celled algae that live in colonies (**figure 8**). A diatom's cell wall is made of silica. Silica is used to make glass. When the diatom dies, its interior **decays**, leaving the skeleton of silica behind. Scientists investigate these skeletons to discover clues about past environmental conditions.

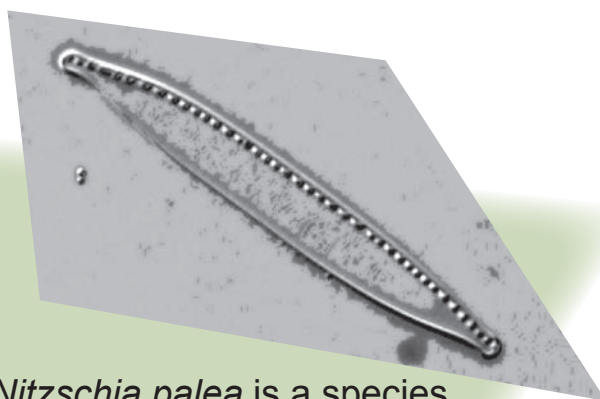


Figure 8. *Nitzschia palea* is a species of diatom. This is an individual diatom. Individual diatoms cannot be seen without a microscope. Photo courtesy of Dr. Hugo Magaña.

The scientist thought that silvery minnows raised in fish hatcheries could be taught to recognize and eat natural food sources, such as diatoms. If silvery minnows could learn to recognize natural food sources while in hatcheries, fewer might die of starvation after their release into the Rio Grande. If fewer minnows die of starvation, the silvery minnow

population might be saved from extinction.

The scientist wanted to answer this question: Can young silvery minnows be taught to recognize natural food sources such as diatoms?



Reflection Section

- ➡ State in your own words what problem the scientist was trying to solve.
- ➡ Use your imagination to brainstorm ways that young silvery minnows might be taught to recognize their natural food sources.

Methods

The scientist used eight aquaria. (Aquaria is the plural form of aquarium.) Each aquarium held 37.85 liters (10 gallons) of water. Two of the aquaria were used for holding fish. Six of the aquaria were used for feeding trials. The scientist **randomly** selected young fish from the two aquaria. Then, the scientist placed 1 fish in each of the six aquaria until 10 fish were in each aquarium (**figure 9**).



Figure 9. The scientist used aquaria to do his experiment. You may have similar aquaria in your classroom or at home.
Photo courtesy of Dr. Hugo Magaña.



The scientist grew diatom colonies in **petri** dishes (**figures 10 and 11**). In this case, a colony is like a community consisting of a large number of tiny organisms. As if using a cookie cutter, the scientist used a cylinder to remove part of the diatom colony from the petri dish. The resulting piece of the diatom colony looked like a hockey puck. The scientist, therefore, called the diatom colony pieces “pucks.”

The scientist placed 6 pucks each on 6 pieces of Plexiglass®. Each puck was the same distance apart. Each piece of Plexiglass® was placed into an aquarium holding the 10 young minnows. To observe the fish, the scientist videotaped each

aquarium. The scientist could, therefore, view the video later and observe the fish (**figure 12**). The scientist timed the number of minutes it took young minnows to locate and sample diatoms from the pucks. This process was repeated six different times.

The scientist then waited between 5 and 17 days. During this time, he fed the young minnows regular aquarium flake food. He then repeated the process used before with the pucks. The purpose of this experiment was to determine whether young minnows that had previous experience would quickly recognize their natural food.

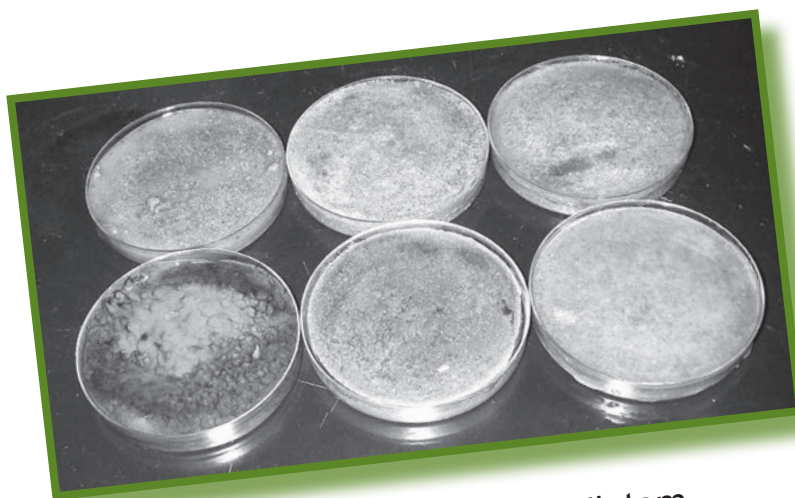


Figure 10. The scientist grew diatom colonies in petri dishes. Photo courtesy of Dr. Hugo Magaña.

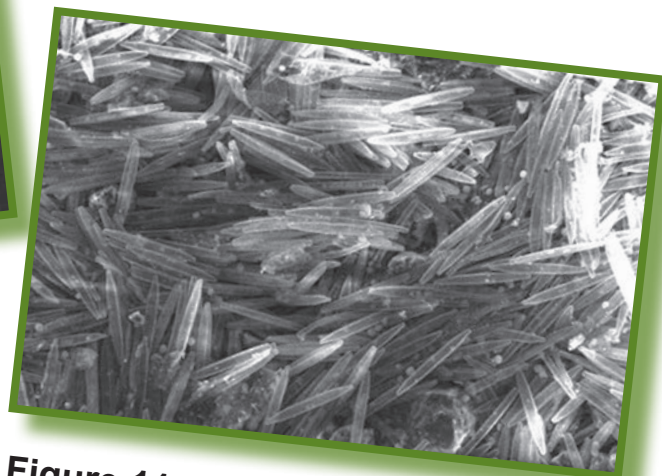


Figure 11. The scientist grew *Nitzschia palea* colonies from samples he collected in the Rio Grande. See Dr. Magaña's photo on page 28. Photo courtesy of Dr. Hugo Magaña.



Figure 12. The scientist used video cameras to observe and record the feeding behavior of young minnows. The cameras were operated by Matt Julius, shown here. Photo courtesy of Dr. Hugo Magaña.

Reflection Section

- ➔ Why did the scientist select the minnows randomly?
- ➔ What is one advantage of using a video camera to observe the minnows' feeding behavior?

Findings

The scientist found that minnows not previously exposed to pucks took an average of 250 seconds to locate the pucks and sample the diatoms (**figure 13**). Minnows introduced previously to pucks took an average of 49 seconds to begin feeding. Some of the minnows began eating from the pucks within 4 seconds.

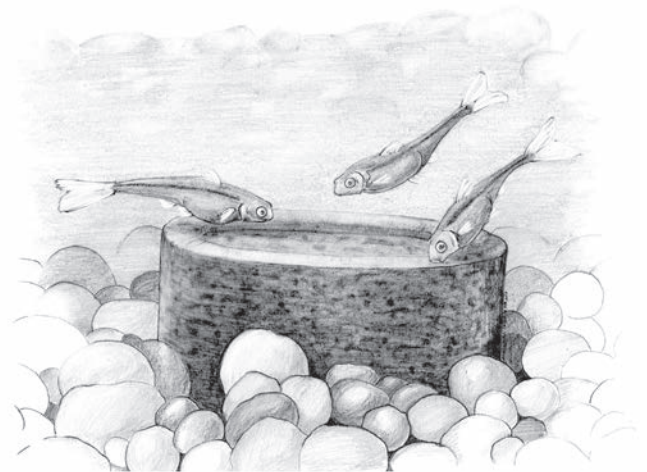
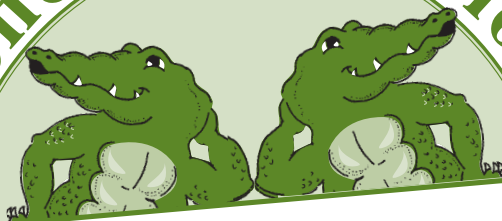


Figure 13. The minnows ate from the diatom pucks. Illustration by Stephanie Pfeiffer.

Reflection Section



- ➔ Based on the findings, what conclusion would you reach about minnows' previous experience with finding and sampling natural food sources?
- ➔ Do you think the timing difference between inexperienced and experienced minnows could be due to something other than previous experience? Why?

Number Crunches



How many whole minutes are contained in 250 seconds?

How many minutes and seconds are in 250 seconds?

Discussion

This study's purpose was to discover if young silvery minnows can learn to quickly recognize and feed on natural foods. If the minnows can learn, they may have a better chance of survival after being released into the Rio Grande. Some silvery minnows learned to locate natural food after just 30 seconds. Days to weeks later, they remembered what they learned. They quickly located the natural food and began eating.

The scientist observed that once the first minnow began eating, other minnows quickly

joined. Another advantage of training minnows is that a trained minnow might be a role model for other minnows. If untrained minnows see a trained minnow sampling a natural food, the untrained minnows may also try the food.

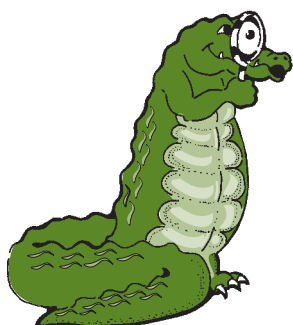
The scientist believes that silvery minnows hatched and raised in fish hatcheries can be taught to identify natural foods. This teaching may help prevent the silvery minnow population from becoming extinct.

Reflection Section

Is it important to save the silvery minnow population from becoming extinct? Why? Is it important to save any species from becoming extinct? Why?

The scientist observed that when other minnows saw one minnow eating, they quickly joined. Name one instance where you observed the same kind of behavior in humans. Your example does not have to be related to food, but to an observation of humans imitating or following others.

Adapted from Magaña, H.A. 2009. Feeding preference of the Rio Grande silvery minnow (*Hybognathus amarus*). Reviews in Fisheries Science. 17(4):468-477. http://www.fs.fed.us/rm/pubs_other/rmrs_2009_magana_h001.pdf.



If you are a trained Project Learning Tree educator, you may use Activity 45: Web of Life or Activity 88: Life on the Edge.

Glossary

abundant (a **bun** dənt): Marked by great plenty.

aquatic (ə **kwä** tik): Growing or living in or often found in water.

debris (də **brē**): The remains of something broken down or destroyed.

divert (də **vərt**): To turn from one course or use, to another.

eddy (e **dē**): A current of air or water running against the main current or in a circle.

endangered (in **dān** jər ed): Being in danger or peril.

extinct (ik **stɪŋ(k)**t): No longer existing.

habitat (**ha** bə tat): The environment where a plant or animal naturally grows and lives.

hatchery (**ha** chə **rē**): A place for hatching eggs.

headwaters (**hed** wä **tərz**): The beginning and upper part of a stream or river.

meander (mē **an** dər): A turn or winding of a stream.

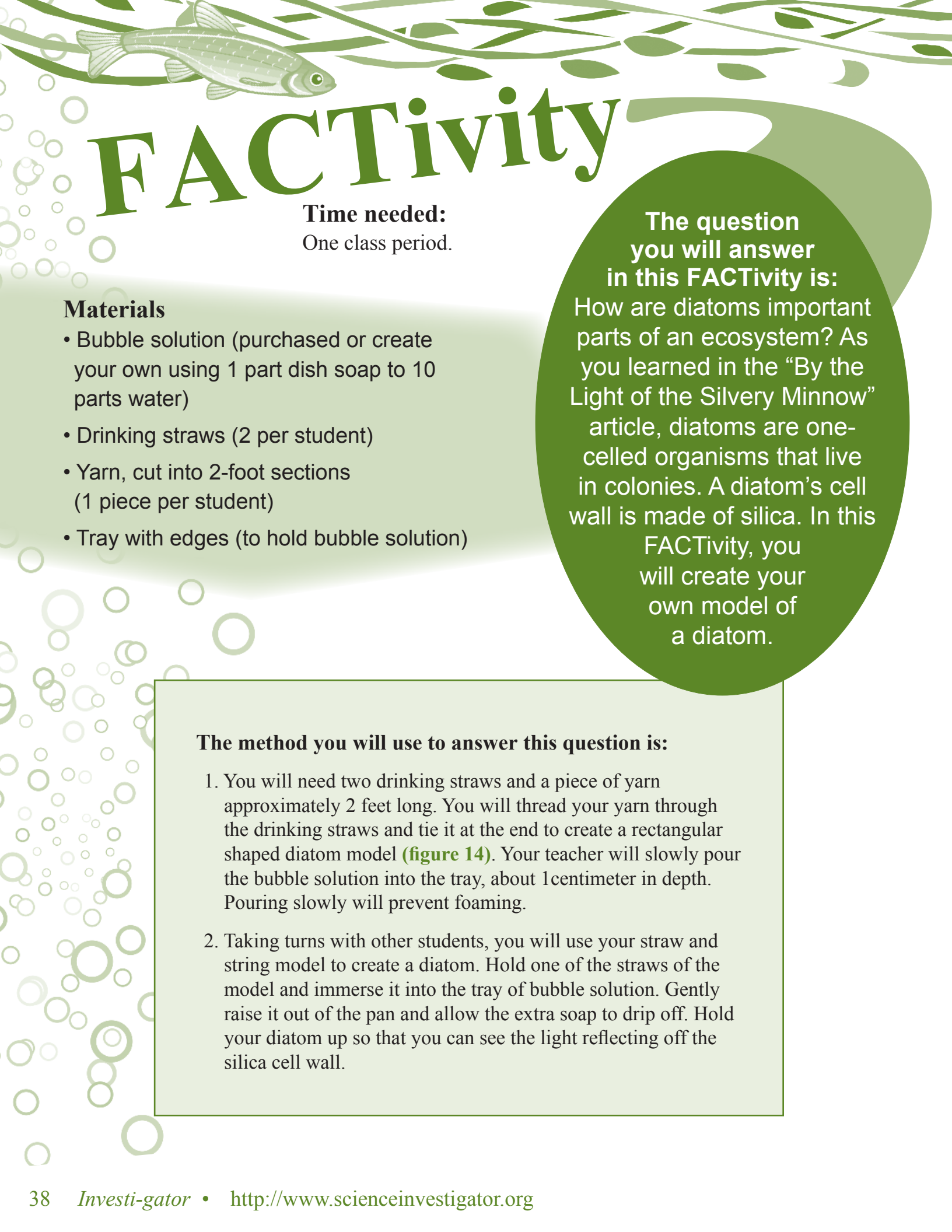
petri (**pē** trē): A small shallow dish with a loose cover used for cultures in science labs.

population (**pä** pyə **lā** shən): A group of one or more species of organisms living in a particular area or habitat.

randomly (**ran** dəm **lē**): Selecting in such a way that each has an equal chance of being selected.

turbid (**tər** bəd): Clouded or discolored by the material from a liquid that settles to the bottom (sediment).

Accented syllables are in **bold**. Marks and definitions are from <http://www.merriam-webster.com>.



FACTivity

Time needed:
One class period.

Materials

- Bubble solution (purchased or create your own using 1 part dish soap to 10 parts water)
- Drinking straws (2 per student)
- Yarn, cut into 2-foot sections (1 piece per student)
- Tray with edges (to hold bubble solution)

The question you will answer in this FACTivity is:

How are diatoms important parts of an ecosystem? As you learned in the “By the Light of the Silvery Minnow” article, diatoms are one-celled organisms that live in colonies. A diatom’s cell wall is made of silica. In this FACTivity, you will create your own model of a diatom.

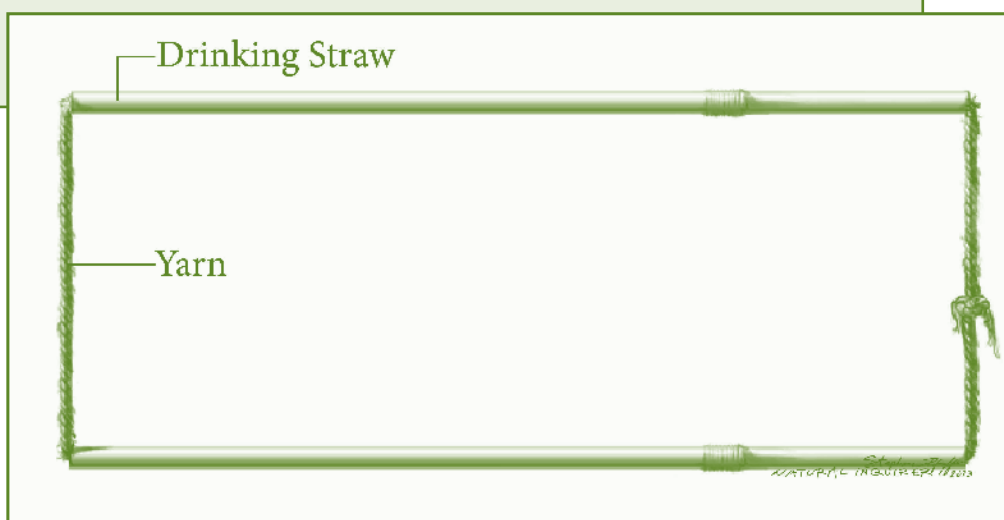
The method you will use to answer this question is:

1. You will need two drinking straws and a piece of yarn approximately 2 feet long. You will thread your yarn through the drinking straws and tie it at the end to create a rectangular shaped diatom model (**figure 14**). Your teacher will slowly pour the bubble solution into the tray, about 1 centimeter in depth. Pouring slowly will prevent foaming.
2. Taking turns with other students, you will use your straw and string model to create a diatom. Hold one of the straws of the model and immerse it into the tray of bubble solution. Gently raise it out of the pan and allow the extra soap to drip off. Hold your diatom up so that you can see the light reflecting off the silica cell wall.

3. After all of your classmates have created a bubble diatom model, your teacher will hold a class discussion about diatoms as a life-form. Some facts you may discuss are:
- a. Diatoms are living aquatic organisms that use sunlight to turn carbon dioxide and water into food and oxygen.
 - b. Diatoms live in both fresh and salt water, in rivers, lakes, and ponds. They can be found throughout the world in areas that are wet.
 - c. Algae are made up of diatoms. The green algae on stones at the water's edge are likely a population of millions of tiny diatoms.
 - d. Diatoms are a basic, natural food source for many other animals, including silvery minnows.
4. Using the article and class discussion as a reference, answer the question posed at the beginning of this FACTivity. Compare your diatom model with figure 8. What are the similarities and differences?

Figure 14: The diatom model will look similar to this when it is completed.

Illustration by
Stephanie Pfeiffer.



Web Resources

Diatoms

<http://www.astrographics.com/GalleryPrintsIndex/GP2006.html/>

How to Make a Diorama Fish Habitat

http://www.ehow.com/how_8304459_make-diorama-fish-habitat.html

Student-based Monitoring Program of the Rio Grande in New Mexico (video)

<http://www.bosqueschool.org/bemp.aspx>

Fish and Wildlife Service-Southwest Region Fisheries Education

<http://www.fws.gov/southwest/fisheries/education.html>

“By the Light of the Silvery Minnow” was taken from a song title. The song is “By the Light of the Silvery Moon.” The song was written and first recorded in 1909 and was performed by Doris Day in 1953. The melody was also recorded by the Muppets in 2011.

Wild Ways

Assessing How Climate Change
May Affect Certain Wildlife

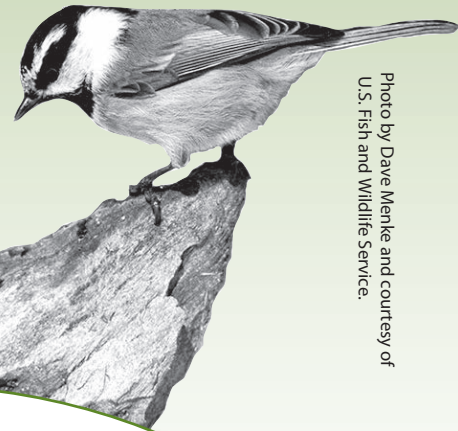


Photo by Dave Menke and courtesy of
U.S. Fish and Wildlife Service.

Meet the Scientists!



Dr. Sharon Coe, wildlife ecologist

I have had wonderful experiences doing science outdoors. One of my favorite experiences was studying a bird. I studied mountain chickadees in a forest in the Sierra Nevada. The Sierra Nevada is a mountain range in California and Nevada. I was collecting data for my Ph.D. degree. People earning a Ph.D. degree become highly **specialized** in one research topic.

I spent many weeks each summer observing the nesting behavior of mountain chickadees. I was able to see eggs and nestlings close-up. I enjoyed learning my way around the woods and knowing where the birds were nesting. My study sites were on lands managed by the Forest Service. After a while, the area became so familiar to me that it felt like it was my backyard. It was a big adventure!



Dr. Deborah Finch, biologist:

One of my favorite scientific experiences is mist-netting and banding songbirds. A mist-net looks like a large volleyball net. The netting is very fine and almost invisible. Birds fly into the netting and get caught. Birds are not injured by mist-nets. After I carefully take each bird from the mist-net, I measure it and put a little numbered metal band around its ankle to keep track of it over time. Then, I love to open up my hands and watch the bird fly away.





Dr. Megan Friggens, ecologist:

My first favorite science experience was taking a 10-day field trip to Belize (bə lēz) as part of a college tropical biology class. Belize is in Central America. This trip was my first opportunity to travel to and live in a tropical jungle. I also explored Belize's **cays** and **reefs**. I saw animals in the wild, such as howler monkeys and barracudas. I did a field study on a plant that eats insects. I also learned a lot about the local human populations. These people were often leading the efforts to **conserve** wild **habitats** and animal **species**. During this time I slept in a hammock, was attacked by tiny biting flies, and swam in crocodile-infested waters (the crocodiles were too small to hurt me). By the end of it all, I knew that I was going to be an ecologist.



What Kind of Scientist Did This Research?

biologist: This scientist studies living organisms and systems.

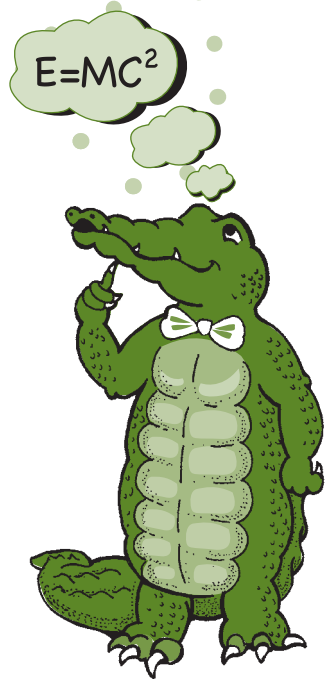
wildlife ecologist: This kind of scientist studies the relationship of different kinds of wildlife with each other and with their living and nonliving environment.

ecologist: This kind of scientist studies the relationship of living things with each other and with the nonliving environment.

Thinking About Science

Sometimes scientists study current problems. Scientists also study problems that may occur in the future. To study what may happen in the future, scientists look at current evidence and make predictions about what might happen.

In this study, the scientists were interested in how a changing climate may affect wildlife in the future. Scientists have tried to figure out the effects of climate change using several different methods. The method the scientists used in this study was to create a **vulnerability index**. A vulnerability index predicts how much a species might be affected by changes to their habitat. The scientists used this vulnerability index to predict which species of wildlife were likely to be the most **vulnerable** to climate change. This process enables people who work to **conserve** wildlife to make better decisions.



Thinking About the Environment

Have you heard the term “climate change?” Climate change refers to how Earth’s climate may be changing over time. In the past few years, most scientists have agreed that measured and recorded changes in Earth’s climate over the past 100 or more years point to a warming of Earth’s surface.

Scientists are researching questions related to the possible effects of climate change. One question is: How do different plant and animal species respond to a changing climate? In this study, scientists were interested in how some **vertebrates** may respond to climate change (**figure 1**).

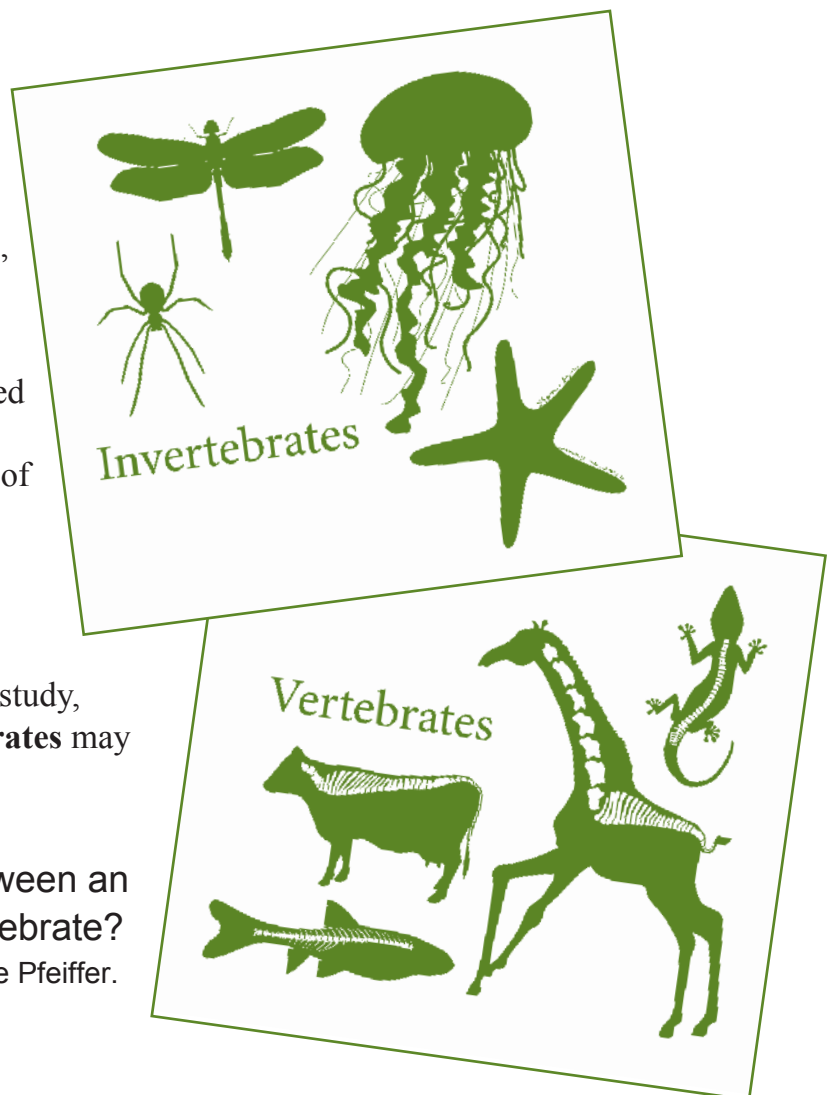


Figure 1. What is the difference between an invertebrate and a vertebrate?

Illustration by Stephanie Pfeiffer.

Introduction

Identifying which species may be the most vulnerable to a changing climate is important. This information can help people make decisions about how to best manage the land. It can also help make better decisions to support wildlife. In this study, the scientists wanted to learn more about species living in and around the Coronado National Forest (CNF) (figure 2). The CNF is located in southeast Arizona and southwest New Mexico (figure 3). The scientists identified 30 species to study.

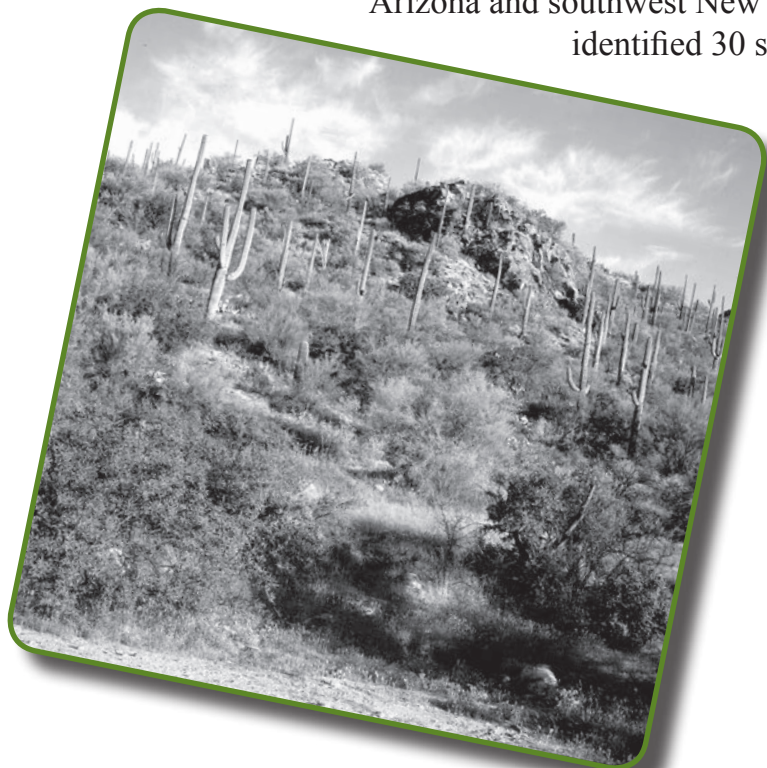


Figure 2. The Coronado National Forest covers 1,780,000 acres of southeastern Arizona and southwestern New Mexico. Photo by Rod Replogle, Forest Service.

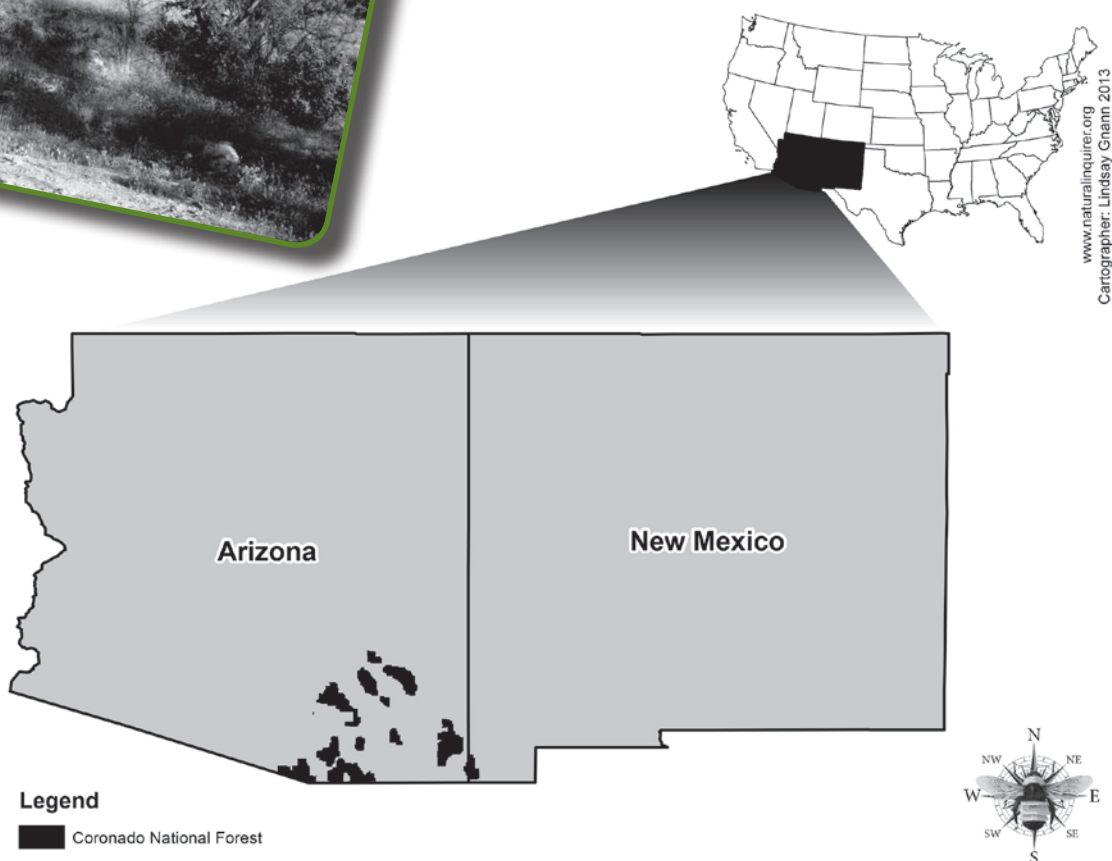


Figure 3. The Coronado National Forest is located in southeast Arizona and southwest New Mexico.

The 30 species the scientists studied included reptiles, amphibians, birds, and mammals (**figures 4, 5a, & 5b**). Some of these 30 species were important to study because they were considered at risk of **extinction**. Some of the species were already listed as an **Endangered Species** or a **Federal Species of Concern**.

Figure 4. The 30 different species that the scientists studied included 8 birds, 13 mammals, 5 reptiles, and 4 amphibians.

Abert's squirrel	Arizona ridge-nosed rattlesnake	Desert tortoise	Mexican long-tongued bat	Northern gray hawk	Townsend's big-eared bat
Allen's lappet-browed bat	Chiricahua leopard frog	Elegant trogon	Montezuma quail	Northern Mexican gartersnake	Western yellow bat
American bullfrog	Chiricahua fox squirrel	Giant spotted whiptail	Mount Graham red squirrel	Slevin's bunchgrass lizard	Western yellow-billed cuckoo
American peregrine falcon	Coues' white-tailed deer	Gould's wild turkey	Northern buff-breasted flycatcher	Sonoran tiger salamander	Western red bat
Arizona gray squirrel	Desert bighorn sheep	Mesquite mouse	Northern goshawk	Tarahumara frog	White-bellied long-tailed vole

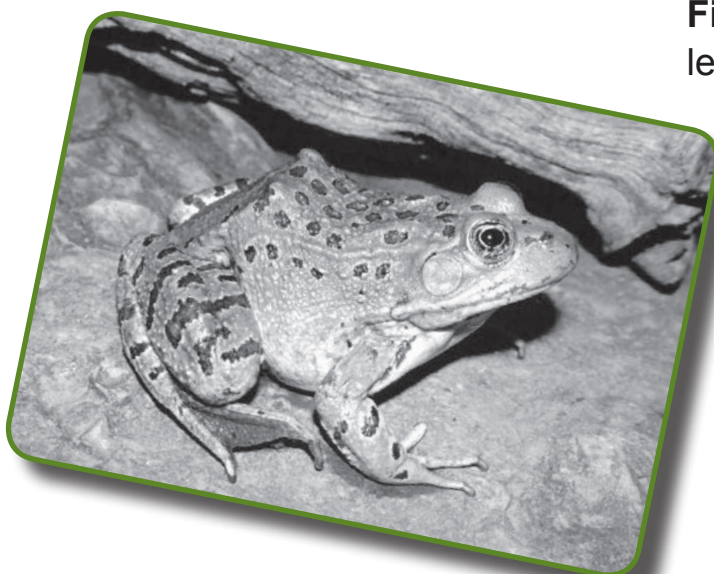


Figure 5a. The Chiricahua (chir ə kă wə) leopard frog is a threatened species. Under the Endangered Species Act of 1973, a threatened species means that the species is “likely to become endangered in the foreseeable future throughout all or a significant portion of its range.” An endangered species is one in which the entire species is in danger of extinction. When a species is extinct, no individuals of that species are alive. Photo courtesy of Jim Rorabaugh, U.S. Fish and Wildlife Service.

Figure 5b. The American peregrine falcon is a fast flier. The falcon averages 25-34 miles per hour in traveling flight. The falcon can reach up to 69 miles per hour when pursuing prey. Photo courtesy of Andrew Kuhn, National Park Service.



The scientists in this study were interested in discovering how climate change may affect the 30 species they studied. The scientists wanted to figure out how **vulnerable** the species may be to climate change.

Reflection Section

➔ In your own words, state what the scientists wanted to know.

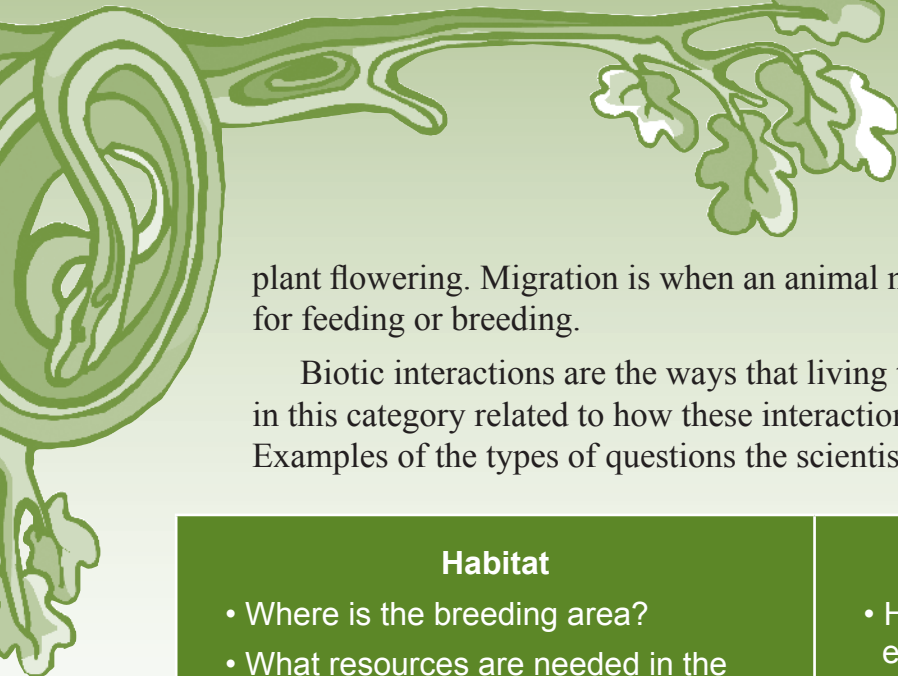
➔ Why do you think the scientists chose some of these 30 species?

Methods

To figure out which species were likely to be the most vulnerable to the effects of climate change, the scientists used a vulnerability index. The scientists answered 25 questions for each species. The 25 questions were grouped into four categories.

The four categories were habitat, physiology (fī zē ā lə jē), phenology (fī nā lə jē), and biotic (bī ā tik) interactions. The habitat category covered topics about where an animal lives. The physiology category covered topics related to the function and activities of the animal.

Phenology is the study of the relationship between climate and events in the annual life cycle of plants and animals. Example topics in the phenology category are bird migration and



plant flowering. Migration is when an animal moves from one region or climate to another for feeding or breeding.

Biotic interactions are the ways that living things interact with each other. The questions in this category related to how these interactions might change due to a changing climate. Examples of the types of questions the scientists answered are shown in **figure 6**.

Habitat • Where is the breeding area? • What resources are needed in the habitat during the breeding season? • Where is the non-breeding area? • How well is the species able to make homes in new areas? • Does the species use migratory areas?	Physiology • How does the species respond to extreme weather? • Would climate change limit the daily active period for the species? • What is the species' life span? • What is the ability of the species to store energy?
Phenology • How does the species use temperature and moisture as cues for changes in behavior? • How many times does the species attempt to breed in a year?	Biotic Interactions • If the species has a specific diet, what are the impacts of climate change on the primary food sources? • Is there potential for changes in the amount that diseases are spread?

Figure 6. Examples of different types of questions the scientists asked in each category.

The scientists answered these types of questions for each of the species in their study. Each question was scored a point value depending on the answer to the question. The scientists calculated an overall score for each species using points from answers to all 25 questions.

The scientists also calculated a score for each species in each of the four categories (using points from only the questions within the category).

In addition, the scientists calculated a score for the four different **taxonomic** groups they studied. They calculated this score by taking the **average** of the overall score for each species in a taxonomic group. The four taxonomic groups that were studied were birds, mammals, amphibians, and reptiles.

In summary, the scientists calculated three scores: 1) an overall score for each species; 2) a score for each category for each species; and 3) a taxonomic group score.

Reflection Section

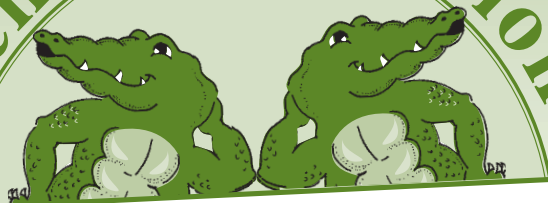


Photo by Fernley and Dreamstime.

➔ Why do you think the scientists looked at an overall score for each species, category scores for each species, and taxonomic group scores?

➔ Look at figure 6 under biotic interactions. Why might it be important to know if there may be a change in the amount of diseases that are spread?

Findings

The scientists found that most of the species were vulnerable to climate change. The overall score ranged from -0.4 to 9.9. The larger the overall score, the more vulnerable the species was to a changing climate.

Sixty-seven percent of the species identified had a score over 5. These were the species most vulnerable to climate change. The two species with the largest scores were the elegant trogon (**trō gän**) and the Tarahumara (**ta rə hü mār ə**) frog (**figures 7 & 8**). The lowest scoring species were the mesquite mouse, the desert bighorn sheep (see photo, upper right), and Slevin's bunchgrass lizard. These three species were predicted to be the least vulnerable to climate change.

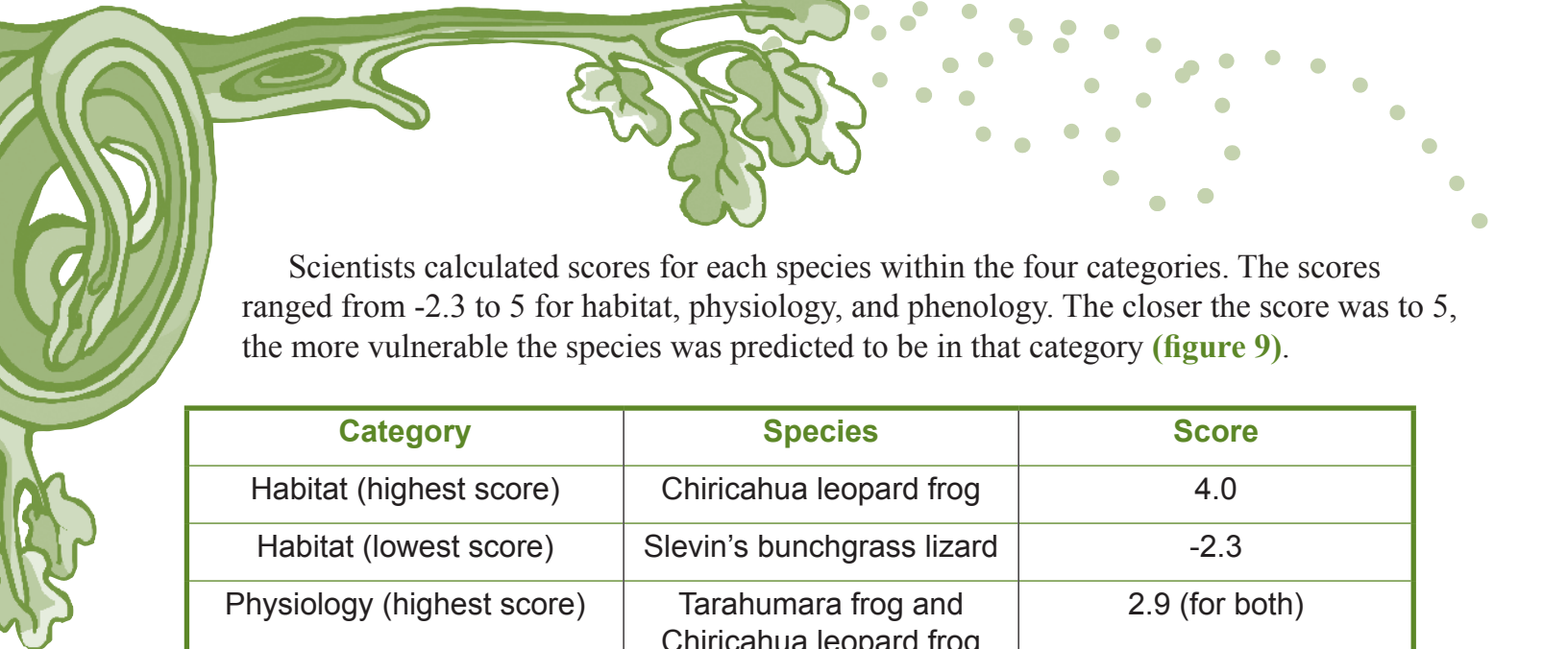


Figure 7. The elegant trogon's population is estimated to be around 200,000 birds. Photo courtesy of Dominic Sherony (Wikimedia Commons).



Figure 8. The Tarahumara frog does not have vocal sacs like most male frogs. Vocal sacs are a thin piece of skin that, when filled with air, enables a male frog to call loudly. The Tarahumara frog still manages to make

sounds, such as grunts and snores, above and below the water. Photo courtesy of Jim Rorabaugh, U.S. Fish and Wildlife Service.



Scientists calculated scores for each species within the four categories. The scores ranged from -2.3 to 5 for habitat, physiology, and phenology. The closer the score was to 5, the more vulnerable the species was predicted to be in that category (**figure 9**).

Category	Species	Score
Habitat (highest score)	Chiricahua leopard frog	4.0
Habitat (lowest score)	Slevin's bunchgrass lizard	-2.3
Physiology (highest score)	Tarahumara frog and Chiricahua leopard frog	2.9 (for both)
Physiology (lowest score)	Townsend's big-eared bat	-0.8
Phenology (highest score)	Elegant trogon	5.0
Phenology (lowest score)	Mesquite mouse	-3.3

Figure 9. The highest and lowest scoring species for habitat, physiology, and phenology. The closer the score was to 5, the more vulnerable the species was predicted to be in each category.

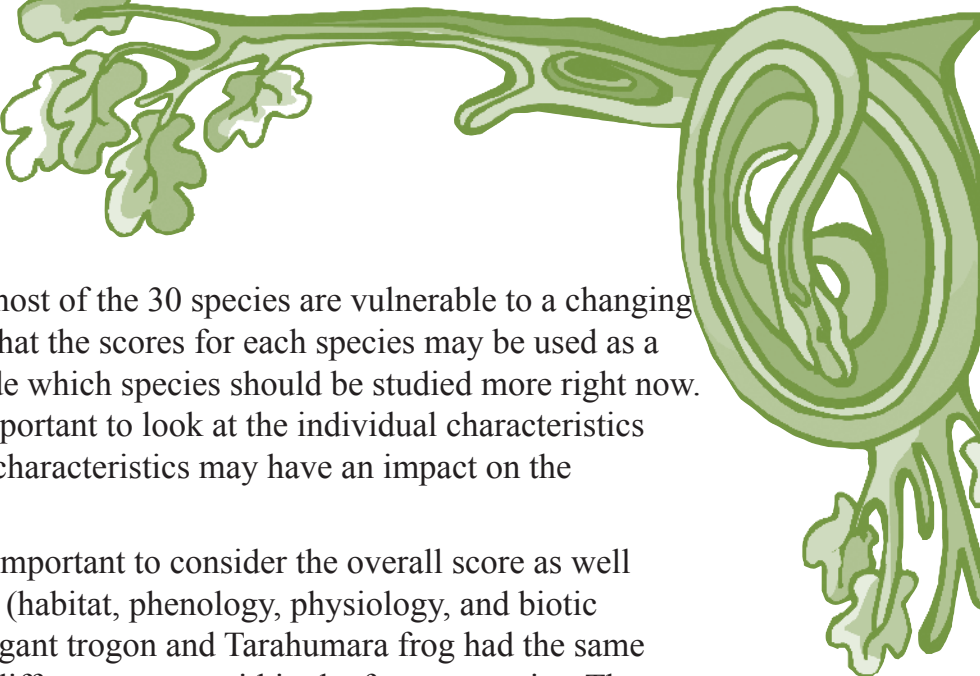
When the scientists looked at the different taxonomic groups they studied, they found that the bird group had the highest average overall score and the reptile group had the lowest average overall score (**figure 10**).

Figure 10. The scores for the taxonomic groups showed that all of the groups were vulnerable to climate change.

Taxonomic Group	Average Overall Score
Birds	7.4
Amphibians	6.9
Mammals	5.0
Reptiles	3.9



- ➡ Look at figure 9. List one thing you notice when studying this table.
- ➡ Look at figure 10. What do you notice about the scores for the four taxonomic groups?

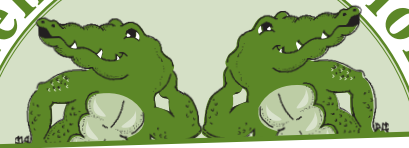


Discussion

The scientists concluded that most of the 30 species are vulnerable to a changing climate. The scientists suggested that the scores for each species may be used as a guide. These scores may help guide which species should be studied more right now. Also, the scientists believe it is important to look at the individual characteristics of each species. These individual characteristics may have an impact on the vulnerability of a species.

The scientists also said it was important to consider the overall score as well as the scores within the categories (habitat, phenology, physiology, and biotic interactions). For example, the elegant trogon and Tarahumara frog had the same overall score. However, they had different scores within the four categories. The scores within the categories may help scientists know which areas need more study.

Reflection Section



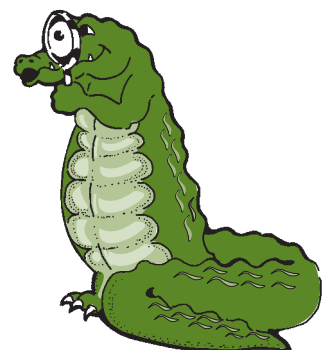
Do you think it is useful to figure out how vulnerable a species is to climate change? Why or why not?



Take a moment to think about all the members of your class. Write down three words to describe your entire class. For example, you could say energetic, smart, and fun-loving. Now take a moment to think about yourself. Write down three words to describe you. Did the three words that you wrote about the entire class and the three words you wrote about yourself match perfectly? How is this like what the scientists found out about the different species when they used the overall score, the category score, and the taxonomic group scores?

Adapted from Coe, Sharon J.; Finch, Deborah M.; Friggens, Megan M. 2012. An assessment of climate change and the vulnerability of wildlife in the Sky Islands of the Southwest. Gen. Tech. Rep. RMRS-GTR-273. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 208 p. http://www.fs.fed.us/rm/pubs/rmrs_gtr273.pdf.

If you are a trained Project Learning Tree educator, you may use Activity 86: Our Changing World or Activity 88: Life on the Edge.



Glossary

average (av(ə-) rij): A value equal to the sum of a set of numbers divided by how many numbers are in the set.

cay (kē): Small, low-lying sandy island formed on the surface of a coral reef.

conserve (kən sərɪv): To avoid wasteful or destructive use of.

endangered species (in dān jər ed spē shēz): A species threatened with extinction.

extinction (ik stɪŋ(k) shən): The state or situation that results when something (such as a plant or animal species) has died out completely.

Federal Species of Concern (fe d(ə-)rəl spē shēz əv kən sərɪn): Species which might need special help. Species of concern do not receive legal protection.

habitat (ha bə tat): The environment where a plant or animal naturally grows and lives.

reef (rēf): A chain of rocks or coral or a ridge of sand at or near the surface of the water.

specialized (spe shə līzd): Trained, or fitted for one particular purpose or occupation.

species (spē shēz): A class of individuals having common attributes and designated by a common name.

taxonomic (tak sǎ nə mik): Orderly classification of plants and animals according to their presumed natural relationships.

vertebrate (vər tə brət): Having a spinal column.

vulnerable (vəl n(ə-) rə bəl): Open to attack or damage.

vulnerability (vəl n(ə-) rə bəl ə tē): The state of being vulnerable.

vulnerability index (vəl n(ə-) rə bəl ə tē in deks): A system for generating a number that indicates how vulnerable something is to something harmful. In this study, scientists collected data about each species and then answered questions about how each species could be affected by climate change. The scientists then were able to calculate numbers, called scores. Higher scores indicated higher predicted vulnerability.

Accented syllables are in **bold**. Marks and definitions are from <http://www.merriam-webster.com>.



FACTivity

Time needed:
Two class periods.

**The question
you will answer
in this FACTivity is:**

How might climate change
affect species in my state?

Materials

- *Investi-gator* Animals and Ecosystems of the Southwestern United States
- Computer with Internet access or hard copy field guides for birds, mammals, reptiles, and amphibians

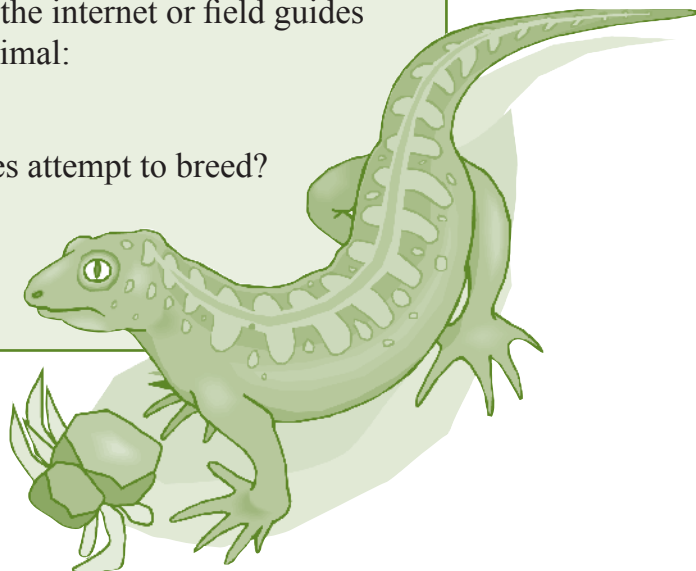


The method you will use to answer this question is:

1. Divide into small groups of three to four students. You and your group will choose four animals that are found in your state. These animals can be birds, mammals, amphibians, or reptiles. One of these animals should be at risk of extinction. This species should be listed as a Federal Endangered Species or a Federal Species of Concern. To find endangered animals in your state, visit the U.S. Fish and Wildlife Service's Endangered Species Program Web site at <http://www.fws.gov/endangered/>.

Once you have chosen four animals, you will answer a few questions to help determine the vulnerability of each animal. Use the internet or field guides to answer the following questions about each animal:

- a. Where is the species' breeding area?
- b. How many times a year does the species attempt to breed?
- c. What is the species' life span?
- d. Does the species have a specific diet?



FACTivity_{continued}

2. After you and your group have answered the questions about each species, discuss the potential impacts climate change could have on these species. Some questions you may ask are:
 - a. How might climate change affect the species' breeding habits? Will it shorten or lengthen the breeding period? Will the species have to travel further to reach its breeding area?
 - b. Will climate change affect how many times a year the species breeds? For example, if it only breeds during the winter and winters become shorter, will the species be able to breed as often?
 - c. How might climate change affect the species' life span? Will the species live for a longer or shorter amount of time?
 - d. How will the species' diet change as a result of climate change? Will the food it eats still be available?
3. As a class, discuss the information you learned about climate change and animals in your state. Compare what you discover with the findings from this article. Now, answer the question posed at the beginning of the FACTivity.

Web Resources

Coronado National Forest

<http://www.fs.usda.gov/main/coronado/home>

Information about the Mexican Frog or Tarahumara Frog

http://www.azgfd.gov/w_c/edits/documents/Ranatara.fi.pdf

Teachers Guide for "Climate Change, Wildlife, and Wildlands Toolkit"

<http://www.globalchange.gov/resources/educators/toolkit>



Photo courtesy of Gila National Forest.

Streaming Live:

*How Do Streams Affect
How Well Trees Use Water?*

Meet the Scientists!



Dr. Darin Law,
plant ecologist:

My favorite science experience was completing a **native** and **exotic** grass study within the University of Arizona Biosphere 2 (**figures 1a and 1b**). Biosphere 2 is a research facility where scientists perform experiments. Biosphere 2 also enables public participation in the scientific process. Biosphere 2 is a large enclosed building that **simulates** different ecosystems.

It was especially fun to talk with students from nearby schools who came to tour Biosphere 2. I told students about the work I do as a scientist. From the time I was young, I watched PBS *Nature* every Sunday evening. This TV show had a tremendous influence on my life. Now, I measure how plants respond to environmental conditions outside and inside Biosphere 2. When I make my measurements, I like to imagine that my work is being filmed for the PBS program *Nature*.



Figure 1a. Biosphere 2 is a large building that is completely closed to the outside environment. Within Biosphere 2, different land and **marine** environments are simulated. Scientific research is done within these environments. Photo courtesy of John Adams, University of Arizona, Biosphere 2.



Figure 1b. Inside Biosphere 2, different environments have been created. This water body simulates an ocean. Photo courtesy of John Adams, University of Arizona, Biosphere 2.



Dr. Deborah Finch,
biologist:

One of my most favorite science experiences was climbing with pack burros to the top of El Triunfo (trī ün fō), a **Biosphere** Reserve in southern Mexico. I was searching for the resplendent (rə splən dənt) quetzal (ket sāl). The resplendent quetzal is a tropical bird with bright green feathers and a long tail. We were setting up a sister forest program with Mexican protected areas. This reserve was famous for protecting this spectacular bird!

What Kind of Scientist Did This Research?

biologist: This scientist studies living organisms and systems.

plant ecologist: This scientist studies the relationships between plants and their environment.

Thinking About Science

Scientists use a lot of interesting and useful instruments. Technology improves the accuracy of scientific measurement. Technology has also enabled scientists to measure some things they could not measure in the past.

In this research, the scientists used a densiometer (**den sē ä mə tər**) to measure the amount of leaf cover (shade) in forested areas. The scientists used a porometer (**pò rä mē tər**) to measure the amount of carbon dioxide (CO₂) entering and the amount of water exiting leaf pores.

The scientists took measurements from thermometers, barometers, and anemometers (**an ə mä mə tərs**). Thermometers measure temperature. Barometers measure atmospheric pressure. Anemometers measure wind speed. The scientists used quantum meters (**figure 1**) to measure the amount of light reaching tree leaves. They used water level meters to measure the distance between the ground's surface and the top level of the water underground (**groundwater**). What do most of these instrument names have in common? What does “meter” tell you when it is the last five letters of a word?

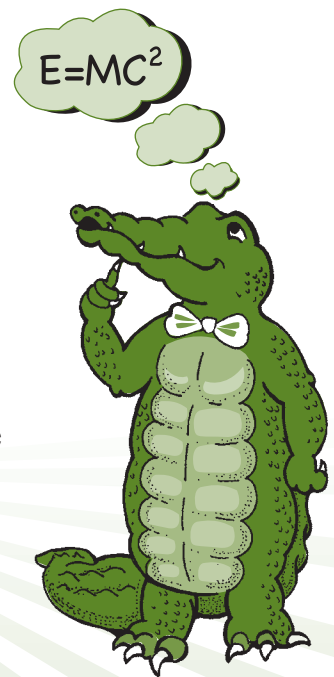


Figure 1. Quantum meters measure the amount of light. Photo courtesy of University of Georgia Warnell School of Forestry and Natural Resources. Photo by Jean Szymanski.

Thinking About the Environment

The Southwestern United States contains much **arid** land (**figure 2**). Arid land has little water. In an area with little water, streams are important. Of all the streams in the Southwestern United States, 19 percent have water all year. The remaining 81 percent are either intermittent (in tə **mit** ənt) or ephemeral (əf ə**m** ər əl) (**figures 3a and 3b**). An intermittent stream has water for only part of the year. An ephemeral stream has water only following rain storms.

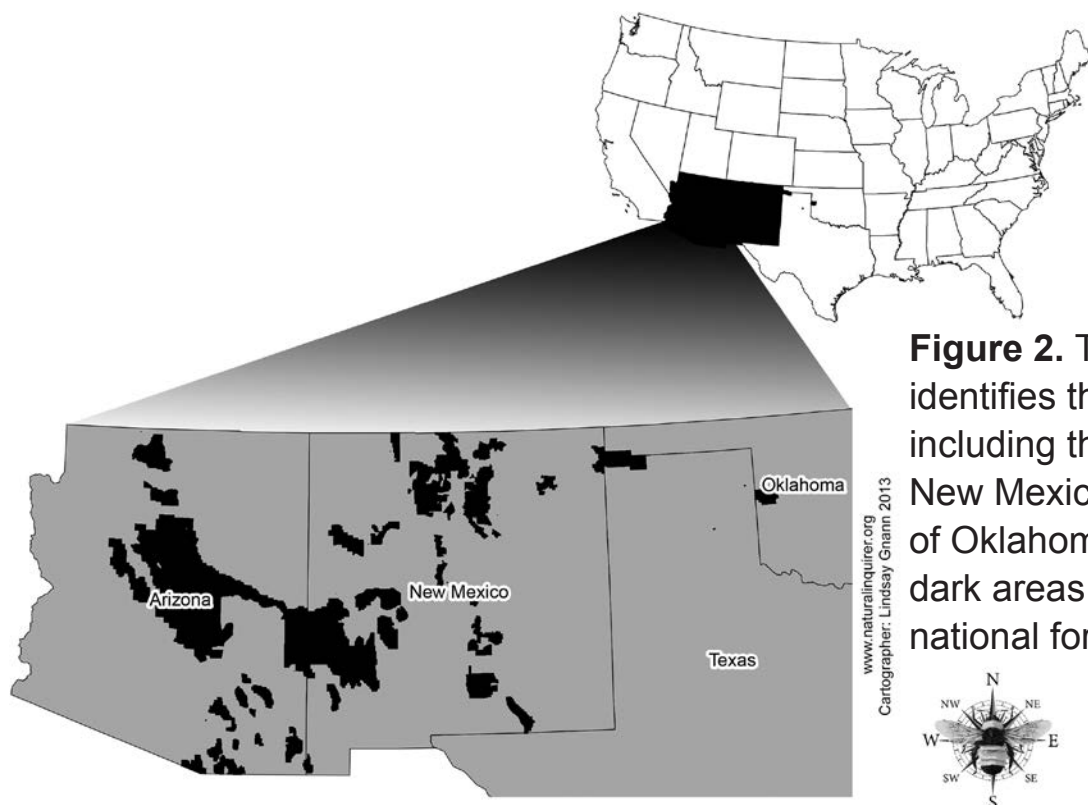


Figure 2. The Forest Service identifies the Southwest as including the states of Arizona, New Mexico, and western parts of Oklahoma and Texas. The dark areas show the location of national forests.

Although intermittent and ephemeral streams may not always have water you can see, these streams contribute to the area's groundwater. Groundwater is water found under the soil's surface. Groundwater from these streams supports plants that otherwise could not live in arid environments. These streams also provide benefits when they have water you can see. These streams provide **breeding habitat** for **amphibians**. Streams also cool the nearby air.

In this research, the scientists were interested in groundwater near intermittent and ephemeral streams. The scientists wondered how trees growing near and away from these streams used available groundwater. Since water is necessary for plants to survive, groundwater is important to plants. This is especially true during times of low or no rainfall, when most available water is groundwater.



Figure 3a. Intermittent streams have water during the rainy season. Ephemeral streams have water only after a rain. This illustration shows either an intermittent or an ephemeral stream during its wet season. Illustration by Stephanie Pfeiffer.



Figure 3b. Intermittent streams are dry during dry seasons. Ephemeral streams are dry between periods of rain. This illustration shows either an intermittent or an ephemeral stream during its dry season. Illustration by Stephanie Pfeiffer.

Introduction

Imagine a tree during times of low or no rainfall. To survive, this tree must use groundwater. Water in arid environments, including groundwater, is **scarce**. Trees, therefore, need to use groundwater **efficiently**.

Groundwater is absorbed by a tree's roots. The groundwater moves upward toward the leaves. The water carries **nutrients** with it (**figure 4**). The leaves use some of the water for **photosynthesis**. Leaves have small openings called stomata. When a leaf's stomata are open, some of the water escapes into the air.

The process of water movement from inside the leaf into the air is called **transpiration**. Water is pulled upward through a tree similar to the way liquid is pulled upward through a

straw. Transpiration helps move water from the ground into the roots, through the stem, and out of the leaves into the air. When stomata close a little or completely, transpiration is reduced or stopped. Think about what happens when the end of a straw is pinched.

Stomata have another job to do. When open, stomata allow carbon dioxide (CO_2) from the air to enter the leaf. In addition to water, trees need CO_2 for photosynthesis (**figure 5**). Photosynthesis is the process whereby trees use sunlight to change CO_2 to high-energy sugar. The trees use the sugar as food. The energy stored in the sugar enables trees to grow.

Open stomata are necessary for photosynthesis. Open stomata, however, can lower a tree's water use **efficiency**. When water is scarce, a tree has to balance transpiration (water loss) with the CO_2 it takes in. When a tree uses scarce water efficiently, two things happen. First, the tree maximizes photosynthesis. Second, the tree minimizes water loss.

The scientists in this study were interested in comparing the water use

efficiency of trees. They wondered if the water use efficiency of trees growing away from intermittent and ephemeral streams was greater than the water use efficiency of trees growing near such streams. Compare this to a person using something more carefully because they only have a limited amount of it. The scientists also wondered if other nearby trees and wind speed affected the water use efficiency of trees.

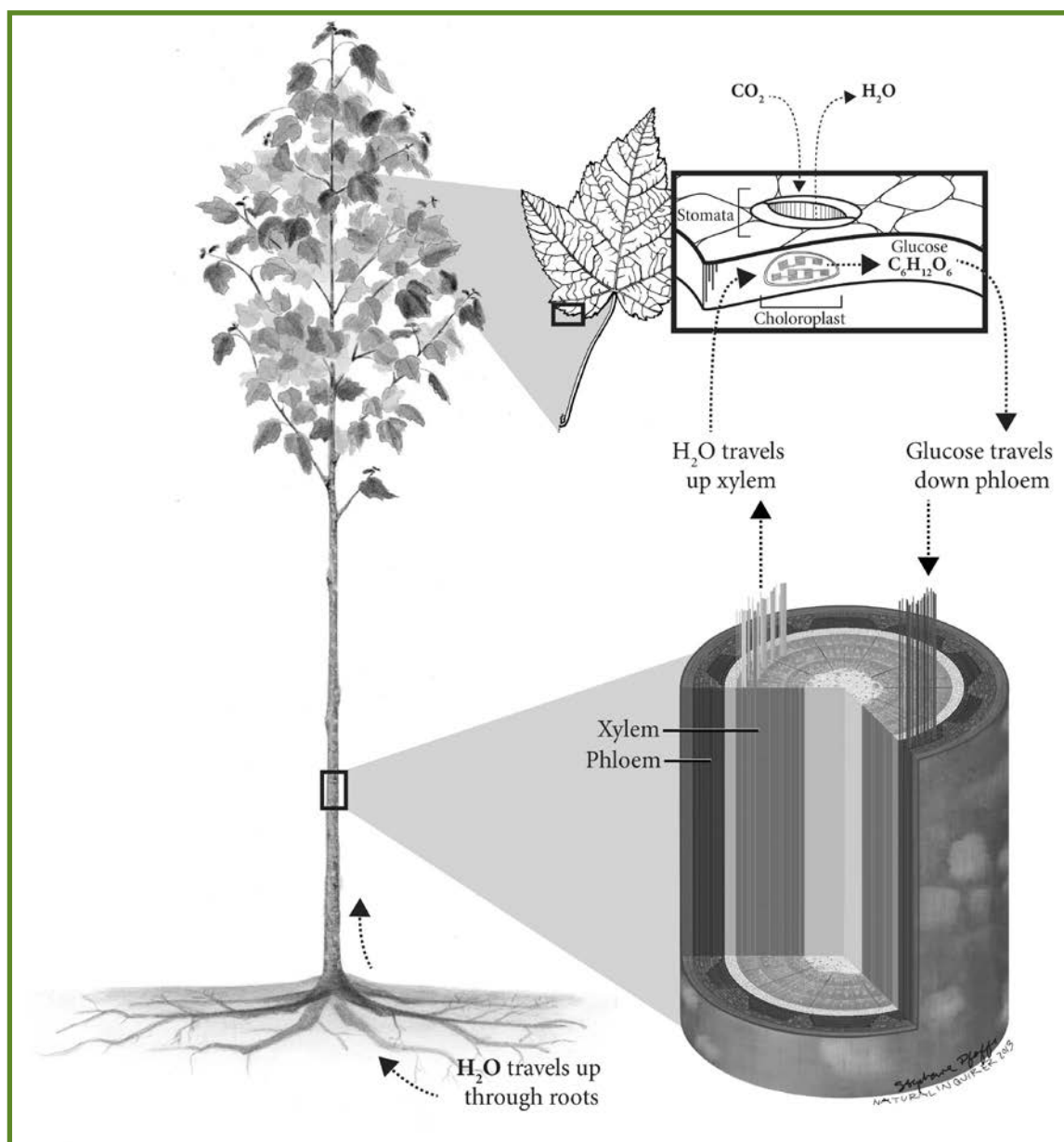


Figure 4. Water is carried upward from a tree's roots through the tree's xylem (zī ləm). Water exits the tree through stomata in the leaves. Illustration by Stephanie Pfeiffer.

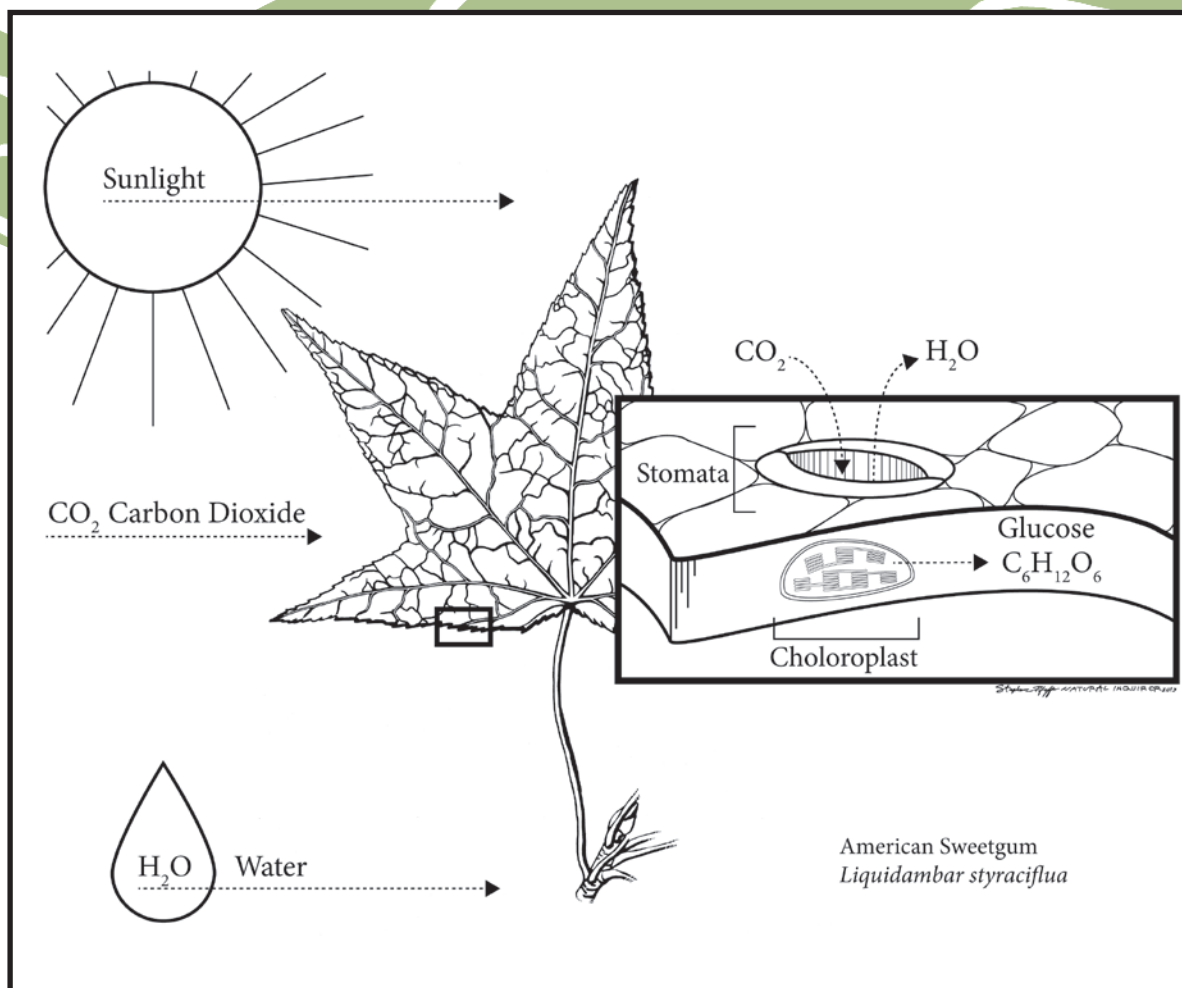


Figure 5. Photosynthesis is the process plants use to convert sunlight into energy in the form of glucose. Illustration by Stephanie Pfeiffer.

Reflection Section

- ➔ What problem do trees face when growing where water is scarce?
- ➔ How might nearby trees affect a tree's water use efficiency?
- ➔ How might wind speed affect a tree's water use efficiency?

Methods

First, the scientists needed to know if areas next to and away from intermittent and ephemeral streams had groundwater. They also needed to know how far the groundwater was from the soil surface. The scientists dug shallow water wells next to and away from intermittent and ephemeral streams and measured the groundwater depth (**figure 6**).

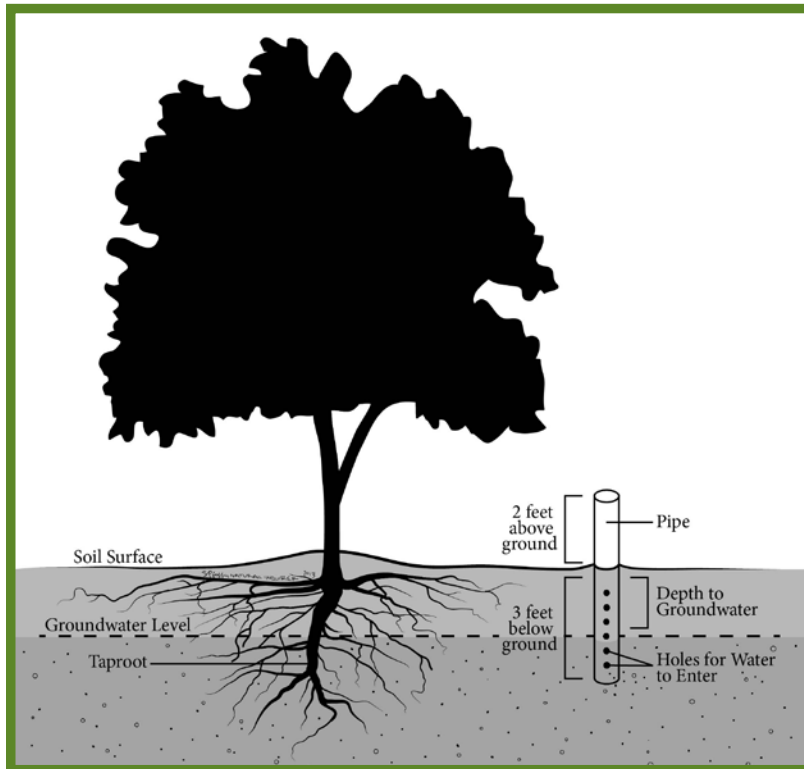


Figure 6. The scientists dug shallow water wells to check for groundwater. The wells were thin pipes with small holes. The pipes were placed deep into the soil. The holes allowed groundwater into the pipe. The scientists then measured the distance between the soil surface and the groundwater in the pipe below the soil surface. Illustration by Stephanie Pfeiffer.

The scientists needed a way to measure the abundance of trees growing in an area. They did this by measuring the amount of shade cover in an area. Shade cover can be measured by the percentage of an area covered by leaves. The scientists also measured air temperature, **relative humidity**, wind speed, and rainfall (**figure 7**). They measured the amount of light reaching the trees (**figure 8**). The scientists measured the amount of CO₂ entering and the amount of water exiting the leaf pores (**figure 9**). The scientists also selected leaves from some of the trees and traced the leaves on paper. They then calculated the area of each leaf to compare leaf sizes from different trees.



Figure 7. Weather stations were set up to measure air temperature, relative humidity, wind speed, and rainfall. This is a weather station at the University of Georgia. Photo courtesy of University of Georgia Department of Geography. Photo by Jean Szymanski.



Figure 8. A densiometer measured the amount of **canopy** cover. Canopy cover is the percentage of leaves shading the ground. Photo courtesy of University of Georgia Warnell School of Forestry and Natural Resources. Photo by Jean Szymanski.

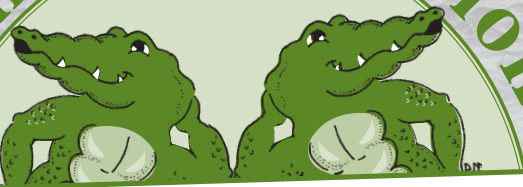


Figure 9. A porometer measured the amount of CO₂ entering and the amount of water exiting a leaf pore. Photo courtesy of University of Georgia Warnell School of Forestry and Natural Resources. Photo by Jean Szymanski.

The scientists used a computer program to compare all of these things. The scientists compared the amount of photosynthesis with the amount of water transpired. This comparison was used as a measure of water use efficiency. The scientists then compared

the water use efficiency of trees growing near and away from intermittent and ephemeral streams. They also compared the water use efficiency of trees growing with many trees nearby and with few trees nearby.

Reflection Section



➡ Why did the scientists need to know how much rain had fallen?

As Earth's climate changes, some areas may receive less rainfall.

➡ Could this research be useful to people living in areas that already have enough rainfall? Why?

Findings

The scientists compared trees in four areas (see figure 10):

1. Areas with many trees growing away from intermittent and ephemeral streams.
2. Areas with many trees growing close to intermittent and ephemeral streams.
3. Areas with few trees growing close to intermittent and ephemeral streams.
4. Areas with few trees growing away from intermittent and ephemeral streams.

The scientists discovered relationships among water use efficiency, photosynthesis, transpiration, and leaf size (**figure 10**).

The areas with highest water use efficiency were the areas with few trees growing away from streams. The areas with lowest water use efficiency were the areas with many trees growing close to streams. High amounts of sunlight and low transpiration seem to favor a more efficient use of water. When water use efficiency is high, leaf size is smaller. When water use efficiency is low, leaf size is larger.

When trees are not growing near each other, wind speed is higher and transpiration increases. When many trees are growing close to each other, wind speed is lower and transpiration decreases.

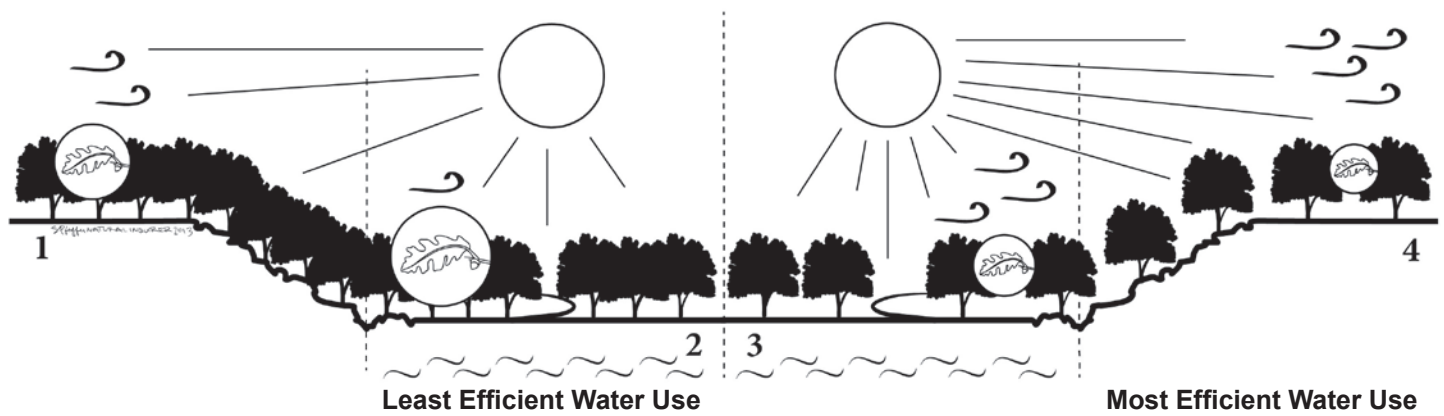
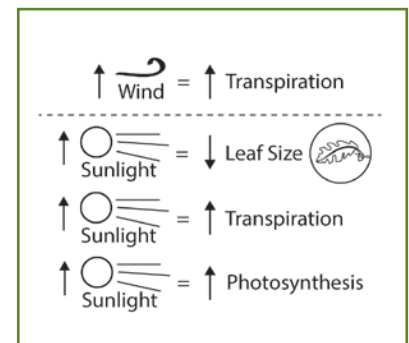
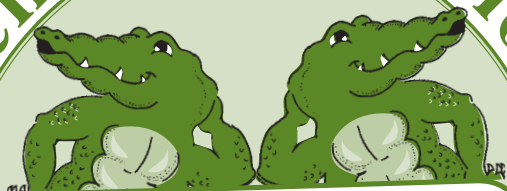


Figure 10. What are the relationships between water use efficiency, leaf size, photosynthesis, and transpiration? Illustration by Stephanie Pfeiffer.



Reflection Section



Look at figure 10. What can you conclude from this figure?

Why do trees growing closer to intermittent and ephemeral streams not need to be as efficient with water use as trees growing away from streams?



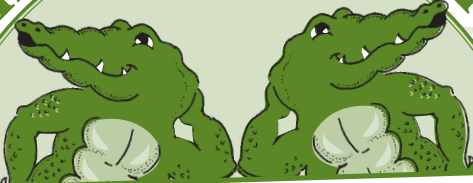
Photo courtesy of Gila National Forest.

Discussion

Based on their results, the scientists suspect something important about CO₂ gain and water loss in trees. They believe that trees work to balance CO₂ gain with water loss to remain healthy. In areas with scarce water, trees try to absorb more CO₂ and transpire less water. To achieve this balance, trees open or close their stomata to increase water use efficiency. If trees are growing close to other trees, the trees increase their leaf size to help absorb more CO₂.

The scientists noted that trees responded to many things in their environment. Trees responded to the amount of light and water available. The trees responded to the number of other trees growing nearby. The trees also responded to wind speed. Trees must respond to all of these conditions. When water is scarce, trees must increase their water use efficiency. They increase water use efficiency by decreasing the amount of water they lose and increasing the amount of light and CO₂ they absorb.

Reflection Section



➡ Are you surprised that trees respond to environmental conditions? Why? What is another example of plants responding to their environment?

➡ In the human body, what mechanism is similar to transpiration?



Adapted from Law, D.J.; Finch, D.M. 2010. Hydrologic, abiotic and biotic interactions: plant density, windspeed, leaf size and groundwater all affect oak water use efficiency. *Ecohydrology*. 4:823-831. http://www.fs.fed.us/rm/pubs_other/rmrs_2011_law_d001.pdf

Glossary

absorption (əb sɔrp shən): The process of taking in.

amphibian (am fɪb bē ən): An organism that lives both on land and in water; a class of cold-blooded vertebrate animals.

arid (a rəd): Excessively dry.

biosphere (bɪ ə sfɪr): The part of the world in which life exists. In this article, Biosphere 2 is the name of a man-made enclosed area that supports life and a biosphere reserve is a protected natural area that supports a diversity of life.

breeding habitat (brēd ɪŋ ha bə tat): An environment where a plant or animal naturally reproduces.

canopy (ka nə pē): Anything that covers like a roof. On a tree, the area of leaves that covers the ground.

decay (di kɑ): To break down, rot, or undergo decomposition.

efficient (i fɪ shənt): Capable of getting desired results without waste.

exotic (ig zä tik): Strange, different, or foreign.

groundwater (graʊnd wä tər): Water that is underground.

habitat (ha bə tat): The environment where a plant or animal naturally lives and grows.

intensity (in ten sə tē): The quality or state of being extreme in strength or force.

marine (mə rēn): Of or relating to the sea.

native (nā tiv): Living or growing naturally in a particular region.

nutrient (nü trē ənt): A substance that plants, animals, and people need to live and grow.

photosynthesis (fō tō sɪn thə səs): The process by which plants turn water and carbon dioxide into food when exposed to light.

relative humidity (rē lə tiv hyü mɪ də tē): The amount of water vapor actually present in the air compared to the greatest amount possible at the same temperature.

scarce (skers): Not plentiful.

simulate (sɪm yə lāt): To create the appearance or effect of something for purposes of evaluation.

transpiration (tran(t)s pə rā shən): The process by which plants give off water vapor through the stomata in their leaves.

unit of measurement (yü nət äv me zhər mənt): A quantity used as a standard of measurement.

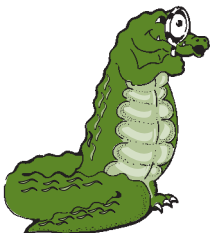
urban forest (ər bən fɔr əst): Trees and other vegetation growing within a city or town.

variable (ver ē ə bəl): Something that, when its quantity is measured, can have a range of different values.

Accented syllables are in **bold**.

Marks and definitions are from

<http://www.merriam-webster.com>.



If you are a trained Project Learning Tree educator, you may use **Activity 41: How Plants Grow** or **Activity 42: Sunlight and Shades of Green**.

FACTivity

Time needed:

One class period and, optionally, an additional 30 minutes in a second class period

Materials

- Access to the Media Center or the Internet
- Graphic organizers on pages 68-69
- “Streaming Live” article

In this FACTivity, you will explore a range of instruments used by scientists. You will then use your imagination to create instruments that measure a range of classroom **variables**.

In this article, the scientists used the following instruments to collect, measure, and record data:

Instrument	Measures
Thermometer	Air temperature
Barometer	Relative humidity
Anemometer	Wind speed
Porometer	Pore opening size (stomata opening size)
Densiometer	Tree canopy cover
Water well meter	Depth from soil surface to ground water
Quantum meter	Light intensity

If you read “Thinking About Science,” you will have a good idea of what the word “meter” at the end of each of these instrument names means. It gives you a clue that the first part of the instrument name tells what variable the instrument measures.

The questions you will answer in this FACTivity are:

1. What are at least five more instruments with the word “meter” in their name, and what variables do they measure?
2. What instrument names can be created for imaginary use in the classroom and what **unit of measurement** would these instruments use?
3. What are the characteristics of a useful unit of measurement?
4. How does having a measurement range help someone to understand the measurement?

The method you will use to answer this question is:

1. Your class should first brainstorm any additional instruments you know ending with the letters “m-e-t-e-r.” These instruments should be written in the graphic organizer given in the next section. You should then do research on the Internet or in your Media Center about scientific instruments. Record any instrument ending with the five letters “meter” and what variable it measures in the graphic organizer. To complete the graphic organizer, you should also fill in the column named “unit of measurement.” The unit of measurement is the numeric unit used to measure the variable. A thermometer, for example, measures the air temperature in degrees Fahrenheit or Celsius. Your class should identify as many instruments as possible.
2. After you have identified instruments, it is time to get creative! Using the second graphic organizer, imagine instruments that measure variables that could be found in the classroom. Below are examples. Remember that these are not real instruments!



Instrument Name	Measures	Unit of Measurement	Measurement Range
Footometer (fö tə mə tər)	Foot length	Inches or centimeters	6 inches-15 inches (15.24- 38.1 centimeters)
Silencometer (sī lən sō mə tər)	The amount of time students have been silent	Seconds or minutes	0-600 seconds or 0-10 minutes
Jumpometer (jum pō mə tər)	How far or high a student can jump	Feet or meters	6 inches-4 feet (0.15-1.22 meters)

3. After the created instruments have been identified and the graphic organizer is completed, your teacher will lead a class discussion about scientific instruments. In particular, you will discuss the need for a clear unit of measurement and a measurement range. Discuss and answer the following questions:

- a. What are the characteristics of a useful unit of measurement?
- b. How does having a measurement range help you understand the measurement?

While doing Internet or Media Center research, other instrument names may have been found. An example is “rain gauge.” You should realize that scientific instruments do not all end with the five letters that spell “meter.”

FACTivity

continued



Your teacher will lead a class discussion in which you explore how the use of scientific instruments helped the scientists in this study do their research.

Scientific Instruments

Instrument Name	Measures	Unit of Measurement

Instruments That Might Be Used in the Classroom

Instrument Name	Measures	Unit of Measurement	Measurement Range

Optional (using an additional 30 minutes at the end of a week): Student teams identify additional real scientific instruments and/or create new imagined instruments over a week's period. The team with the longest (and best documented) list of instruments wins. All listed instruments, whether real or imagined, must include the four columns shown in the second graphic organizer. Students will present their instruments and the class will pick the team winner.

For a FACTivity about leaf transpiration, see the FACTivity for the "Woolly Bully" monograph at <http://www.naturalinquirer.org>.



Web Resources

Weather instruments

[http://www.weatherwizkids.com/
weather-instruments.htm](http://www.weatherwizkids.com/weather-instruments.htm)

Biosphere 2

<http://www.b2science.org/>

What is a densiometer?

[http://www.youtube.com/watch?v=nTc_
sqUPVZo](http://www.youtube.com/watch?v=nTc_sqUPVZo)

We need trees!

[http://kids.discovery.com/tell-me/earth/
why-do-we-need-trees](http://kids.discovery.com/tell-me/earth/why-do-we-need-trees)

Do trees grow on farms?

<http://www.realtrees4kids.org/index.htm>

PRAIRIE DOG DAYS

How Fleas Transmit the Plague and
its Effects on Gunnison's Prairie Dog



Meet the Scientists!



Dr. Megan Friggens, ecologist

My first favorite science experience was taking a 10-day field trip to Belize (bə lēz) as part of a college tropical biology class. Belize is in Central America. This trip was my first opportunity to travel to and live in a tropical jungle. I also explored Belize's **cays** and **reefs**. I saw animals in the wild, such as howler monkeys and barracudas. I did a field study on a plant that eats insects. I also learned a lot about the local human populations. These people were often leading the efforts to **conserve** wild **habitats** and animal **species**. During this time I slept in a hammock, was attacked by tiny biting flies, and swam in crocodile-infested waters (the crocodiles were too small to hurt me). By the end of it all, I knew that I was going to be an ecologist.

Dr. Bob Parmenter, chief scientist, biologist, and ecologist

My favorite science experience was (and still is) tracking the recovery of the plants, fish, and wildlife following the very large Las Conchas wildfire. This wildfire burned through northern New Mexico in the summer of 2011. I monitor the populations of bears, mountain lions, elk, deer, squirrels, mice, birds, salamanders, and fish. I also monitor invertebrates, including grasshoppers, beetles, spiders, ants, wasps, butterflies, and moths. It's fascinating to see how all these species respond to large forest fires in New Mexico.



Dr. Paulette Ford, ecologist

My favorite science experiences are when I am outside at my experimental research sites. I love to be outside studying plants and animals! As a scientist, I also get to travel around the world to talk about my research and to explore different ecosystems. I've been to grasslands, forests, jungles, deserts, mountains, oceans, rivers, and swamps all over the world. I never stop learning, and that is big fun!



Dr. Kenneth Gage, medical entomologist and zoologist

My favorite science experience happened while working at the Centers for Disease Control and Prevention. I was traveling to a remote village in the Andes Mountains of Peru. An outbreak of plague was occurring in the village. Plague is a rare but dangerous disease that can be fatal if not quickly treated with the right medicines. Humans can get the disease when they are bitten by infected fleas or handle infected animals.

In the village, some people had become sick after handling infected animals. Others had become ill after being bitten by infected fleas found in their homes or fields. The village could not be reached by road. My

Peruvian colleagues and I had to ride mules up a very narrow trail that often passed by steep slopes and cliffs. In addition to riding mules, we also used seven small donkeys to carry the equipment and supplies needed to control the outbreak.

At one point, a rope used to tie some of the equipment to one of the donkeys broke. This caused the donkey to begin kicking. As it kicked, the equipment bounced up and down, making loud noises that frightened the mules and donkeys and caused them to begin braying loudly. At the same time, my mule started to buck, causing the stirrup on my saddle to break off. At that point, I was barely holding on and thought I was going to be bucked off my mule and over a cliff. Fortunately, I was able to hang on and made it safely to the village. The people there treated us kindly and greatly supported our work, making this trip a memorable and rewarding experience.

In this photo, I am investigating a case of human plague.





What Kind of Scientist Did This Research?

ecologist: This scientist studies the relationship of living things with each other and with the nonliving environment.

chief scientist: This scientist leads other scientists in a particular research area.

biologist: This scientist studies living organisms and systems.

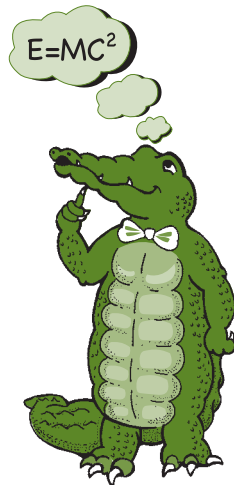
medical entomologist: This scientist studies medically important arthropods, such as fleas, ticks, and mosquitoes.

zoologist: This scientist studies animals and animal life.

Thinking About Science

When scientists start a research project, they must do several things. First, they identify the problem they are interested in researching. Second, scientists develop a research question. Next, they design a study that helps them answer their research question.

It is not easy to design a study to answer a research question. To design a study, scientists must read a lot about the topic of interest. Scientists also need to find out if other research has been done on this topic. If other research has been done, scientists learn about what the other scientists did and how it applies to their new study. After scientists have done this reading and research, they design their study. In this article, scientists designed a research study to learn more about how **plague** affects prairie dogs and their environment. Plague is a disease that is easily spread to other animals.



Thinking About the Environment

A prairie dog is not really a dog! It is a large ground squirrel, a type of **rodent**, which lives on the **prairie** (figures 1a, 1b, and 2).

Prairie dogs get their name from where they live and the “barking” sound they make. Prairie dogs make this sound to communicate with other prairie dogs.





Figures 1a and 1b.

Prairies are wide open spaces with grasslands and very few trees.

Photos courtesy of U.S. Fish and Wildlife Service.



Figure 2. A white-tailed prairie dog standing guard. Photo courtesy of U.S. Fish and Wildlife Service.

Prairie dogs are social animals that live in large underground **burrows** (figure 3). These underground burrows are called towns. Prairie dog towns are built by prairie dogs. The burrows have many long tunnels and rooms. The burrows have rooms used as nurseries, sleeping areas, and even bathrooms! When a female prairie dog is ready to have a baby, she goes into the nursery and gives birth to her baby. A baby prairie dog is called a “pup.” Pups are hairless and don’t open their eyes until they are about 6 weeks old.

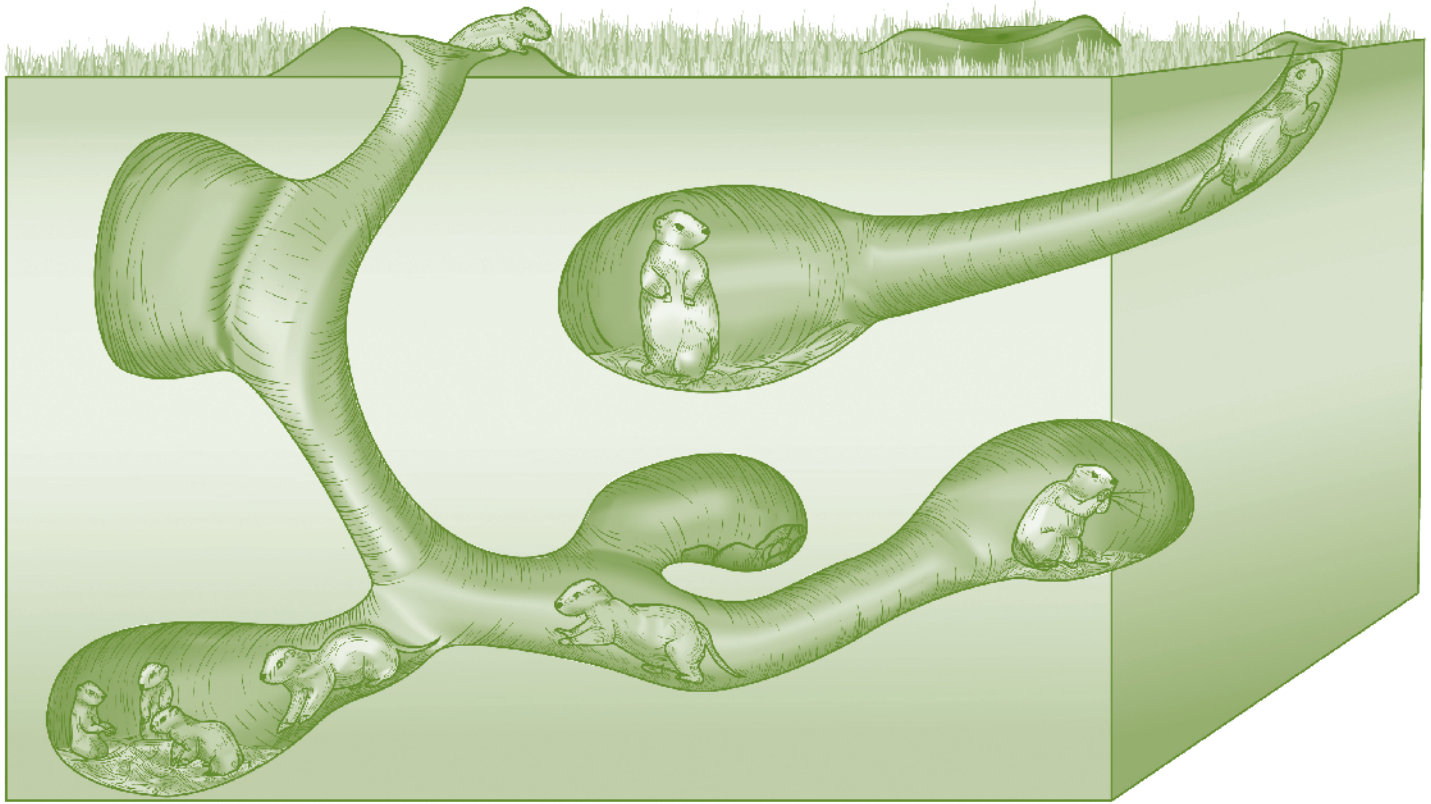


Figure 3. Prairie dog towns have many tunnels and “rooms.”

Illustration by Samantha Bond.

Prairie dogs feed on grasses, roots, and seeds. In the past, ranchers thought prairie dogs were bad for ranch land because they would eat the grasses and dig holes in the soil (**figure 4**). Cows and horses might accidentally step into the holes and hurt their legs. Because some ranchers thought prairie dogs were a problem, some people worked to get rid of prairie dogs. Scientists believe the prairie dog population has declined to a small percentage of what it was. An effort to get rid of prairie dogs, however, is not the only reason the prairie dog population is declining. In this article, you will learn about another problem prairie dogs are facing.



Figure 4. Two prairie dogs sitting near the entrance of their burrow.

Photo courtesy of the National Park Service.

WHY ARE PRAIRIE DOGS IMPORTANT?

Some efforts are underway to increase the populations of prairie dogs. A number of experts argue that prairie dogs are good for the ecosystem because they help **aerate** the soil. Aerating the soil helps more water get into the soil. Additionally, prairie dog scat or “poop” is high in nitrogen, which is good for the soil. Nitrogen is a **nutrient** used by plants and soil **bacteria**. Several predators, such as snakes and ferrets, rely on prairie dogs for food.

Introduction

Fleas present a problem for prairie dogs. Fleas are tiny, wingless insects that feed on the blood of other animals (**figure 5**). Fleas can **transmit** diseases to other animals. Fleas transmit diseases by biting a diseased animal and carrying the disease to the next animal they bite. Plague is an **infectious** disease that is transmitted to other **mammals** by fleas. Prairie dogs are particularly **susceptible** to plague.

Prairie dogs are susceptible to plague for two reasons. First, prairie dogs have no natural **immunity** to plague. Second, prairie dogs live in large colonies with complex burrow systems. Burrows, and the large number of animals in a small area, are good conditions for fleas to survive and reproduce. More fleas in burrows greatly increase the chances of prairie dogs getting plague.

Plague is dangerous to all mammals. About 95 percent of the prairie dogs living in a colony may die from plague if exposed to it. The high death rate of prairie dogs exposed to plague also affects animals that depend on prairie dogs for food. An example of an animal that depends on prairie dogs is the black-footed ferret (**figures 6a and 6b**). The scientists in this study were interested in figuring out which flea **species** transmit plague within a population of prairie dogs. The scientists also wanted to know if the burrows played a part in the plague outbreaks.



Figure 5. Fleas can transmit diseases to mammals such as prairie dogs. Photo courtesy of Thinkstock.com.



Figure 6a. A black-footed ferret looks over his shoulder. Photo courtesy of U.S. Fish and Wildlife Service.



Figure 6b. A black-footed ferret peeks out of a prairie dog hole. Photo courtesy of U.S. Fish and Wildlife Service.



- ➔ What are the questions the scientists want to answer?
- ➔ Prairie dogs have no natural immunity to the plague. Think about some things to which humans are not immune. Why do you think a strong immune system is helpful? What are some ways you can help protect yourself from illness?

Number Crunch

Ninety-five percent of the prairie dogs in a colony may die from being exposed to plague. If 100 prairie dogs are exposed to the plague, how many would probably survive?

Methods

The scientists conducted their study in Valles Caldera National Preserve in New Mexico (**figure 7**). The scientists specifically studied the Gunnison's prairie dog (**figures 8 and 9**). The study was completed over 3 years from 2004-2006. The study areas were located in **montane** grassland habitats. Montane grasslands are grasslands located in high elevations. Three grassland habitats were selected: 1) Redondo Meadow, 2) El Cajete, and 3) Valle Grande (**figures 10a and 10b**).

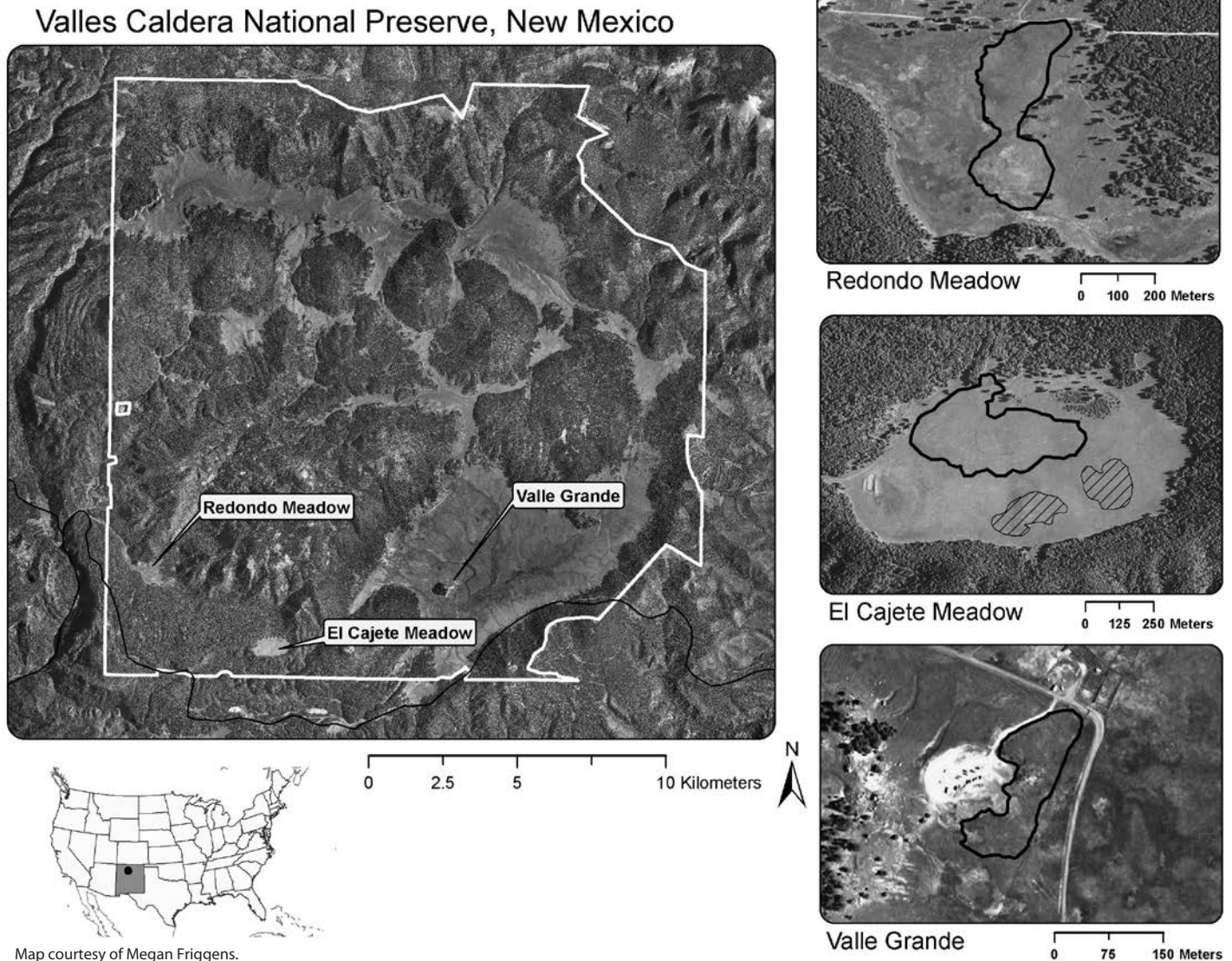


Figure 7. Valles Caldera National Preserve is located in New Mexico.



Figures 8 and 9. Gunnison's prairie dogs. What do you notice about prairie dogs that may be useful for where they live? Photos by Lisa Lynch, National Park Service.



Figure 10a.
El Cajete is a montane grassland. Montane grasslands are located at high elevations. Photo courtesy of www.vallescaldera.gov.



Figure 10b. Valle Grande is the largest grassland in the Valles Caldera National Preserve. Only one road goes through this grassland. Look closely and you may be able to see the road in this photo. Photo courtesy of www.vallescaldera.gov.

WHAT IS ELEVATION?

Elevation is the distance above a reference point. When we talk about the elevation of land, the reference point is the level of the sea (**figure 11**). The areas in this study were between 2,460 and 2,640 meters above sea level. Compare this to one of the highest points of elevation in the world, Mount Everest, which is 8,848 meters above sea level. One of the lowest land elevations in the world is the area where the Dead Sea is located. The Dead Sea is located in the Middle East. The Dead Sea area is over 400 meters (over 1,300 feet) below sea level. The lowest land elevation in the United States is in Death Valley, California. The elevation in Death Valley is 86 meters (282 feet) below sea level. Do research about areas around where you live and see how their elevations compare!

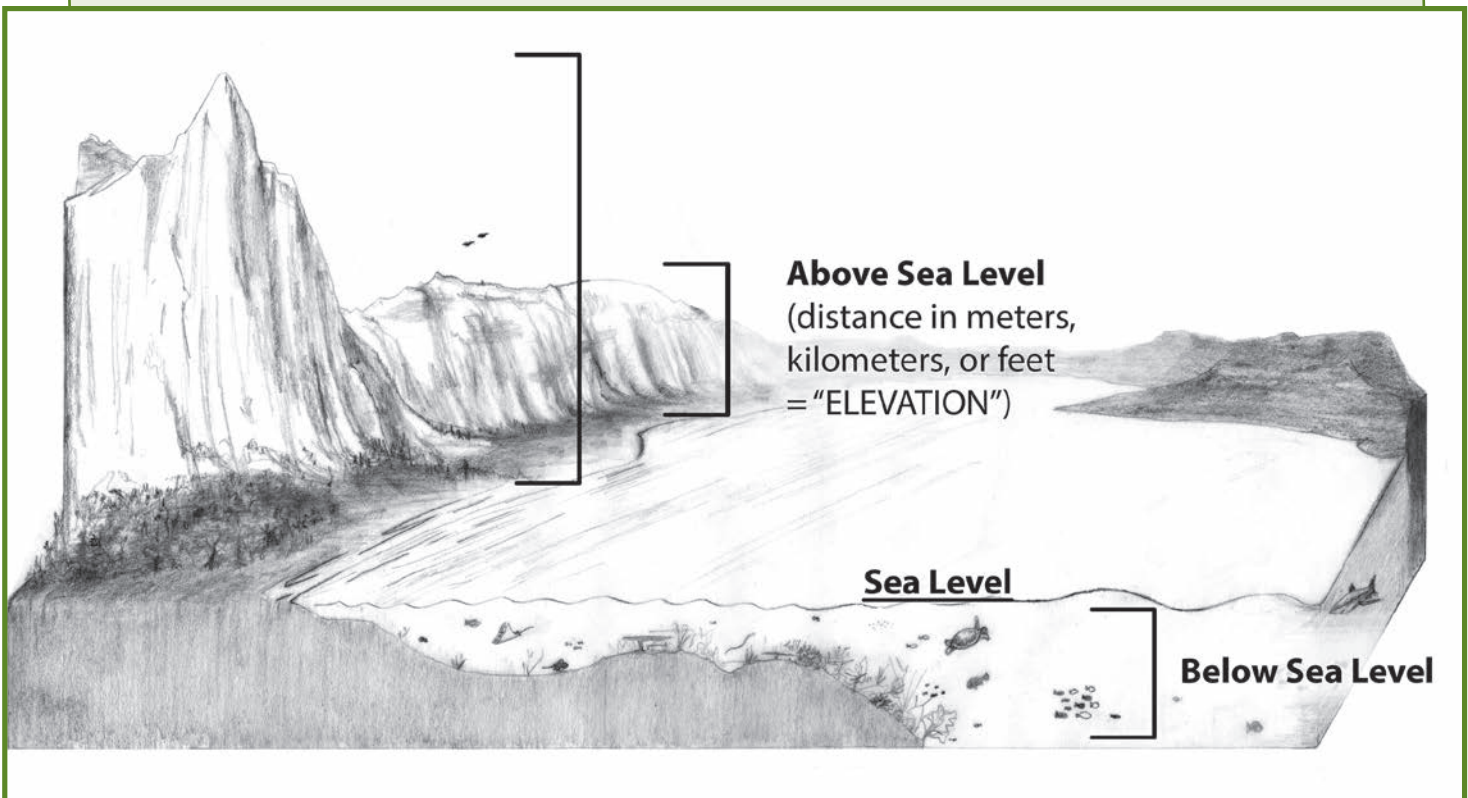


Figure 11. Elevation is the distance above or below the level of the sea.

Illustration by Stephanie Pfeiffer.

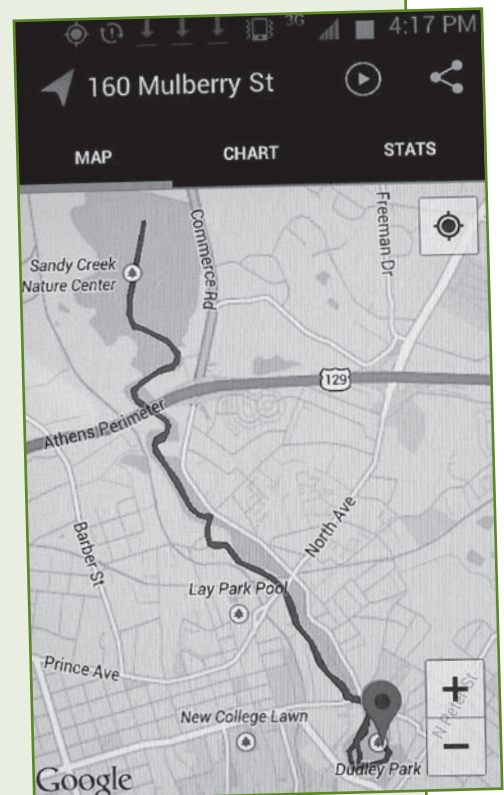
The scientists examined each colony. During their study of the colonies, the scientists did several things. They live-trapped prairie dogs (**figure 12**). Live-trapping is a technique where animals are trapped for science research. They are not harmed and they are released back to their environment. The scientists did this in the spring and summer each year. During the first trapping session, the scientists marked and took global positioning system (GPS) **coordinates** of active burrows. GPS coordinates help scientists specifically locate and map areas such as prairie dog burrows.



Figure 12. Scientists captured this Gunnison's prairie dog for their study. The prairie dog is caught in a live-trap. This trap does not hurt the prairie dogs and when the scientists are finished working with the animals, the animals are released back into their habitat. Photo courtesy of Megan Friggens.

WHAT IS A GLOBAL POSITIONING SYSTEM (GPS)?

A GPS is a navigation system. GPS stands for Global Positioning System. A GPS can tell the exact coordinates of where you are located on Earth. A GPS works by using satellites orbiting Earth to send information to GPS receivers. At any time, at least three satellites are able to send signals to any receiver on Earth. GPS was designed in 1973 by the United States military. The military designed GPS to help soldiers and military vehicles find their exact location anywhere in the world. Today, GPS units are used in a wide variety of ways. Often, cell phones have GPS receivers and you may even have a GPS device in your car that tells you directions!



The scientists identified an active burrow by looking for scat (or “poop”), scratch marks on the ground near burrow entrances, or the presence of a lot of flies at each burrow entrance. If a burrow appeared abandoned, then the scientists made a note of this and chose a new burrow close by.

The burrows and prairie dogs were examined for the presence of fleas. When prairie dogs were captured, the scientists held them over a plastic bin containing a felt cloth. They brushed the fur with a flea comb or toothbrush. After brushing, the fleas fell into the plastic container and onto the cloth. They were then collected by the scientists.

The scientists collected fleas from the burrows. The burrows were swabbed by attaching a white flannel cloth to the end of a plumber’s snake (figure 13). The scientists pushed the plumber’s snake down into the tunnels. The scientists extended the plumber’s snake at least 1 meter (3.281 feet) into the burrow and held it there for 30 seconds. The scientists wiggled the flannel while down in the hole to imitate an animal. Sometimes the scientists blew on the flannel to attract fleas since fleas are also drawn to carbon dioxide.

The scientists took the plumber’s snake out and then placed the flannel cloth into a plastic bag so the fleas could be collected. The scientists identified and examined the fleas using a dissecting microscope (figure 14). Blood samples were taken from the fleas to test for plague.

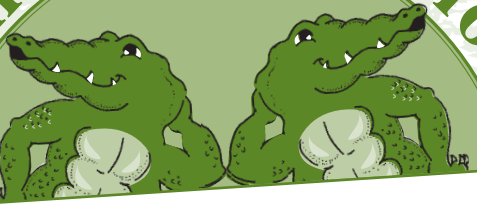


Figure 13. The scientists used a plumber’s snake and other equipment to collect fleas. Photo courtesy of Megan Friggens.



Figure 14. A dissecting microscope is useful for examining very small animals or objects. In this study, the scientists used the dissecting microscope to identify what type of flea they had found. A dissecting microscope enables scientists to see the sample in 3-D. Photo by Jessica Nickelsen.

Reflection Section



The scientists used flannel cloth to capture fleas. Why do you think they used this kind of material? Do you think a slick surface would have been as effective at capturing the fleas? Why or why not?

The scientists used a dissecting microscope to identify the fleas. Why do you think the microscope was used instead of just looking at the fleas with the naked eye to figure out what species they were?

Findings

The scientists examined 130 prairie dogs. The scientists collected 633 fleas from prairie dogs and 167 fleas from burrows (**figure 15**).

Where the fleas were found	Flea species	Spring	Summer	Total
Burrows	<i>Catallagia decipiens</i>	1	1	2
	<i>Oropsylla hirsuta</i>	85	47	132
	<i>Oropsylla idahoensis</i>	16	4	20
	<i>Oropsylla tuberculata cynomuris</i>	7	1	8
	<i>Oropsylla tuberculata tuberculata</i>	5	0	5
Gunnison's prairie dogs	<i>Oropsylla hirsuta</i>	79	507	586
	<i>Oropsylla idahoensis</i>	5	23	28
	<i>Oropsylla tuberculata cynomuris</i>	14	0	14
	<i>Oropsylla tuberculata tuberculata</i>	3	2	5

Figure 15. Flea species and the number collected from burrows and Gunnison's prairie dogs caught in Valles Caldera National Preserve in northern New Mexico.

The scientists found that *Oropsylla hirsuta* and *Oropsylla tuberculata* were the two primary flea species involved in outbreaks of plague. It had been reported that *Oropsylla hirsuta* is the most important flea because of how fast it transmits the plague among prairie dogs.



➔ Look at Figure 15. What do you notice about the number of fleas present between the spring and the summer? Why do you think there might be this difference?

➔ What species of flea was most commonly found on the Gunnison's prairie dog? In the burrows? Why do you think this might be important information for the scientist to know?

Discussion

The scientists know that an important flea species for transmitting plague is *Oropsylla hirsuta*. This species was found in the largest numbers on the prairie dogs and in the burrows. This finding supports the idea that *Oropsylla hirsuta* may be the flea species that causes transmission of plague in prairie dogs in the Valles Caldera National Preserve.

The scientists believe that burrows are an important factor in the transmission of the plague. Burrows are good places for fleas to live and reproduce. Fleas can also easily move from one rodent to another in the burrows. Even after the plague has killed off a large portion of the prairie dogs in a particular area, fleas can live for several more months. Therefore, other rodent populations that come into the burrows may be infected by the fleas that are still living there.



➔ Do you think it is important for scientists to study how the plague affects the prairie dogs? Why or why not?

➔ Does this research have any importance for understanding how fleas might transmit diseases between other types of mammals? Why or why not?

Glossary

aerate (er āt): To supply with air.

bacteria (bak **tir** ē ə): A group of microscopic, single-celled organisms that live in all environments.

burrow (bər ō): A hole in the ground made by an animal.

cay (kē): small, low-lying sandy island formed on the surface of a coral reef.

coordinate (kō **ord** nət): Any of a set of numbers used to locate a point on a line or surface or in space.

immunity (i **myū** nə tē): The power of the body to resist an infectious disease.

infectious (in **fek** shəs): Capable of causing infection.

mammal (ma məl): Any of a class of warm-blooded vertebrates. This includes people and other animals that feed their young with milk from mammary glands. Their skin is usually more or less covered with hair.

montane (măn **tān**): Of, relating to, growing or being in the zone of moist cool upland slopes below tree line.

nutrient (nū trē ənt): A substance that plants, animals, and people need to live and grow.

plague (plāg): A serious disease that is caused by a bacterium, occurs or has occurred in several forms including bubonic plague, and is usually passed to human beings from infected rodents and especially rats by the bite of a flea or is passed directly from person to person.

prairie (prer ē): A large area of level or rolling grassland.

rodent (rō dənt): Any of an order of fairly small mammals that have sharp front teeth used for gnawing.

species (spē shēz): A class of individuals having common attributes and designated by a common name.

susceptible (sə **sep** tə bəl): Having little resistance.

transmit (trans **mit**): To transfer from one person, animal, or place, to another.

Accented syllables are in **bold**. Marks and definitions are from <http://www.merriam-webster.com>.

Web Resources

National Geographic Prairie Dogs

<http://animals.nationalgeographic.com/animals/mammals/prairie-dog/>

National Zoo Prairie Dogs

<http://nationalzoo.si.edu/Animals/NorthAmerica/Facts/fact-pdog.cfm>

Adapted from Friggens, M.M.; Parmenter, R.R.; Boyden, M; Ford, P.L.; Gage, K.; Keim, P. 2010. Flea abundance, diversity, and plague in Gunnison's prairie dogs (*Cynomys gunnisoni*) and their burrows in montane grasslands in northern New Mexico. *Journal of Wildlife Diseases*. 46(2) pp:356-367. <http://www.ncbi.nlm.nih.gov/pubmed/20688629>.

If you are a Project Learning Tree educator, you may use Activity 26: Dynamic Duos or Activity 45: Web of Life.



FACTivity

Time needed:

One class period

Materials

- “Prairie Dog Days” article
- Copies of the prairie ecosystem food web sheet on page 87, one for each student
- Pencil, one for each student

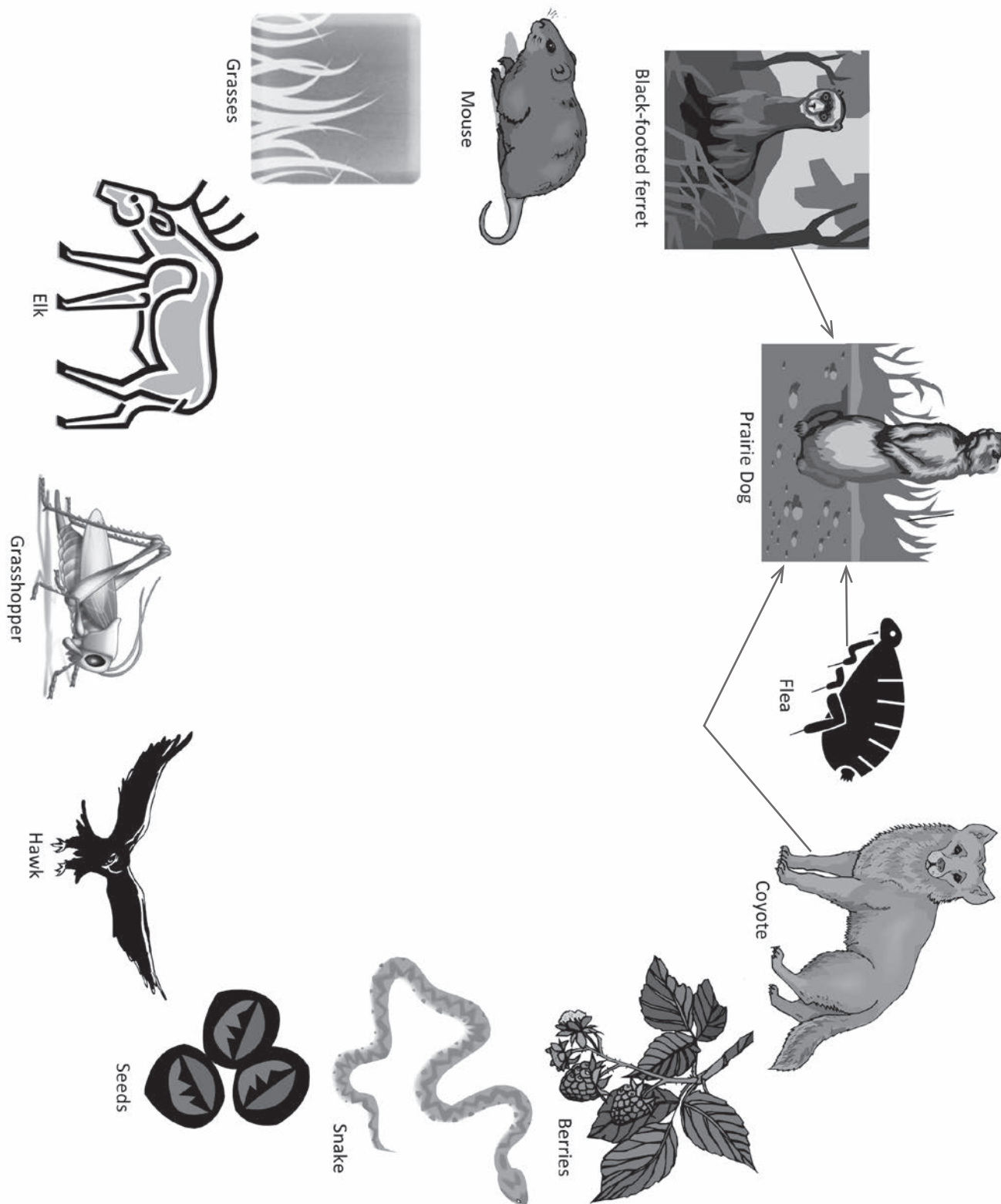
The question you will answer in this FACTivity is:

How does the decline of prairie dogs affect the prairie food web?

The process you will use to answer this question is:

1. Look at the animals and plants found in the prairie ecosystem food web.
2. Draw arrows to connect the animals between predators and the prey they eat. The arrow should be drawn from the predator to the prey. In other words, the arrow should point to the thing that is eaten. A few connections have been drawn for you. Reference the “Prairie Dog Days” article if you need help figuring out the connections. If your teacher allows it, you can also work together with your classmates. Note: More than one connection can be drawn between the animals.
3. Using the completed food web, answer the following questions:
 - a. What animal and/or plants are at the lowest level of the food web?
 - b. What do prairie dogs eat?
 - c. What animals feed on prairie dogs?
4. Next, cross out the prairie dog. Placing an “X” over the image represents the decline or removal of prairie dogs from the food web. Using the revised food web, answer the following questions:
 - a. How does the food web change when prairie dogs are removed?
 - b. Will animals that feed on prairie dogs have other food options?
 - c. How will populations change without the prairie dogs? For example, will any animal or plant populations grow or shrink in numbers?

PRAIRIE ECOSYSTEM FOOD WEB EXAMPLE



FACTivity Extension:

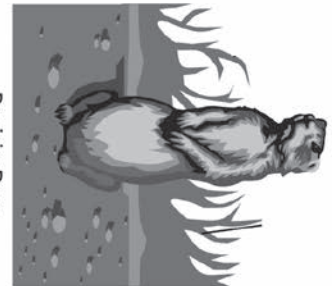
Complete an additional food web removing prairie dogs from the ecosystem. Discuss as a class how the rest of the ecosystem would be affected if prairie dogs were removed from the habitat.

STUDENT NAME: _____

PRAIRIE ECOSYSTEM FOOD WEB



Black-footed ferret



Prairie Dog



Flea



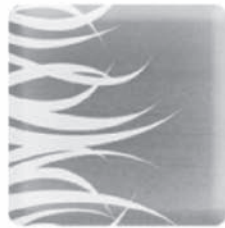
Coyote



Berries



Snake



Grasses



Mouse



Elk



Grasshopper



Hawk



Seeds

THE LANDS OF TIME

Understanding Land Grants in New Mexico

Meet the Scientists!

Dr. Carol Raish

social scientist and anthropologist

Some of my favorite science experiences are listening to older people talk about the way things were in the past when they were young. I also love to travel to talk with people all over the world.



Ms. Alice McSweeney

social science analyst

My favorite science experience is talking with ranchers to learn how they teach their children about the land and animals. I also love working on my family's guest ranch in northern New Mexico. I have a Master's degree in Range Science. Range scientists study rangeland plants and animals and how best to manage the land for these plants and animals.



What Kind of Scientist Did This Research?

anthropologist (an(t) thrə pä lə jist): This scientist studies societies and cultures.

social science analyst: This scientist assists social scientists as they study the values, opinions, beliefs, attitudes, and actions of individuals and groups of people.

social scientist: This scientist studies the values, opinions, beliefs, attitudes, and actions of individuals and groups of people.

Thinking About Science

Social scientists study people. Anthropology (**an(t)** thrə pǎ lə jē) is one of the social sciences. Anthropology is the study of people in societies and cultures. Societies and cultures include particular groups of people. Societies and cultures can include groups of people who lived during a certain time and in a certain place. Societies and cultures can also include groups

of people who make, for example, a particular type of art or music. Any group can have its own culture. Your school, for example, might have its own culture, different from other schools. Do you think a city school's culture is different from a **rural** school's culture in the United States? How might these cultures be different? How might they be similar?



Thinking About the Environment

Native peoples lived in Mexico until the Spanish invaded in the 16th century. Mexico won its independence from Spain in 1821. Mexico once contained almost twice as much land as it does today (**figure 1**). New Mexico, now a state in the United States, was once a part of Mexico.

New Mexicans who lived in northern New Mexico during this time owned two types of land. Individual families owned a small piece of land for their house and a garden. Other large areas of land were shared by the community. The lands were granted to individuals and communities by the Spanish and Mexican governments. This ownership system was called land grants.

When the United States government gained Mexico's northern territory in 1848,



www.naturalinquirer.org
Cartographer: Lindsay Gann 2013

Figure 1. Before 1845, Mexico included what became the Republic of Texas. The Republic of Texas became a part of the United States in 1845. Between 1845 and 1848, Mexico was made up of current-day Mexico, plus California, Nevada, Utah, Arizona, and parts of Colorado and New Mexico.

it promised to respect the New Mexicans' land grants. These New Mexicans became United States citizens in 1848 following the Mexican-American war. In this article, these citizens will be called Hispanic ranchers to reflect their ethnic background and how they used land.

To keep their land grants, the Hispanic ranchers had to apply to the United States government. Most of the Hispanic ranchers were not awarded their land grants. One reason was that the Hispanic ranchers did not speak English. Because they did not speak English, they did not have the information to correctly apply for the land grants. Many

were also cheated out of their land by dishonest lawyers they hired to help them. Much of the land lost by these Hispanic ranchers became **national forests (figures 2, 3, and 4)**. In this article, you will learn about the **descendants** of these ranchers. You will learn how some of these descendants are trying to regain the land grants owned by their **ancestors**.

Figure 2.
The Carson
and Santa Fe
National Forests
in northern New
Mexico.

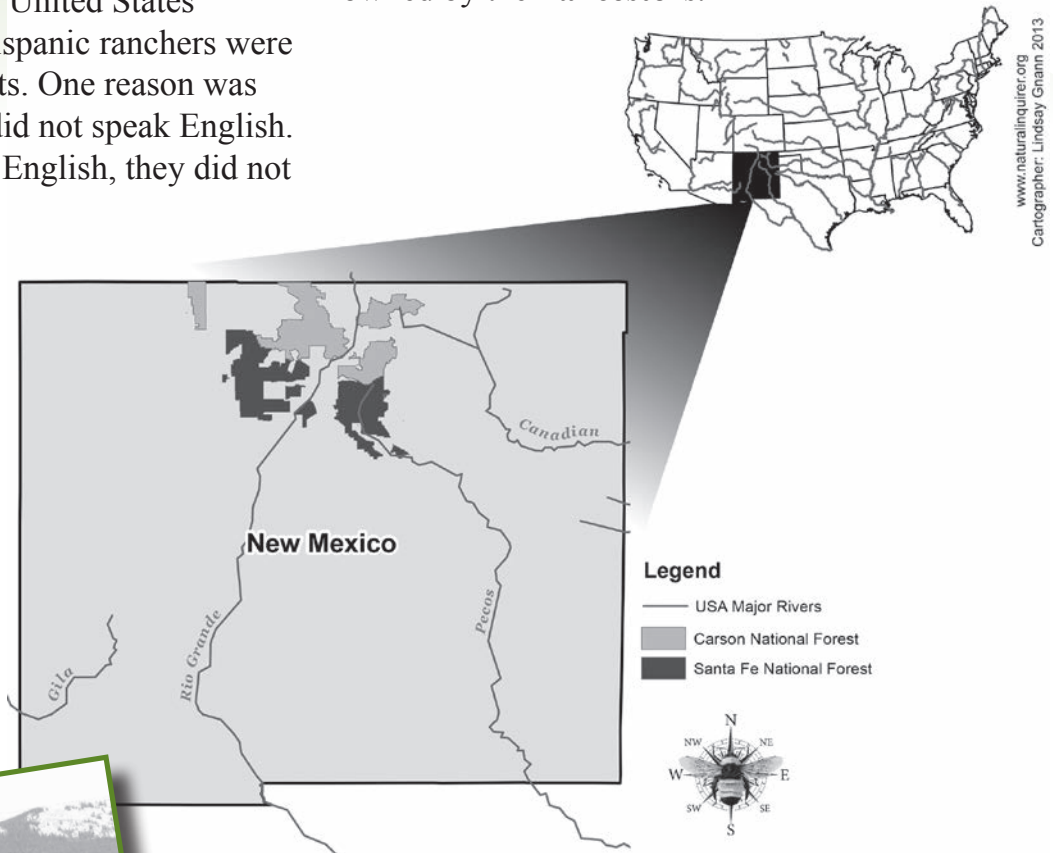


Figure 3. The Carson National Forest.
Photo courtesy of the U.S. Forest Service.



Figure 4. The Santa Fe National Forest.
Photo courtesy of the U.S. Forest Service.

What is the Treaty of Guadalupe Hidalgo?

The Treaty of Guadalupe Hidalgo is the treaty that ended the Mexican-American War. This war was fought between the United States and Mexico between 1846 and 1848. The United States gained land from the treaty that ended the war. The United States gained California and a large area containing what is now Arizona, New Mexico, Nevada, Utah, and parts of Wyoming and Colorado (**figure 5a**). In the treaty, the Rio Grande was established as the border between Texas and Mexico (**figure 5b**). The United States promised to honor the land grants as a part of the treaty. These land grants had been granted to Hispanic ranchers by the Spanish and Mexican governments.

Figure 5a. The states of the United States that were gained following the Mexican-American War. During this time, these states were still one territory. In 1912, New Mexico became the 47th state in the United States. You can do research to discover when the other states gained statehood.

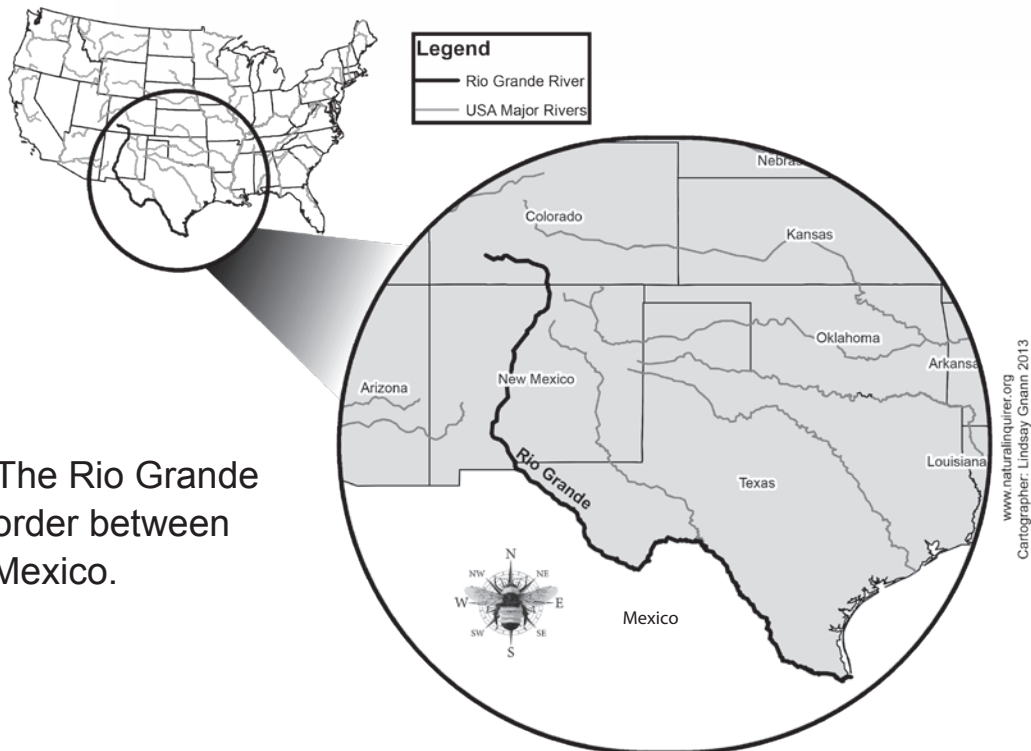


Figure 5b. The Rio Grande forms the border between Texas and Mexico.

Introduction

National forests and national **grasslands** are managed for all United States citizens. Parts of these forests and grasslands, however, may be **leased** to individuals and companies. Some individuals and companies lease **public land** to graze sheep and cattle (**figure 6**). They may also lease public land for other purposes, such as to mine for minerals. In New Mexico, these lands were once shared by the Hispanic community in a system of land grants. Today, some Hispanic people in New Mexico feel they have a right to regain some land. They feel this way because

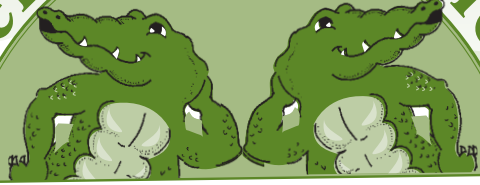
they believe the land grants were unfairly taken from their ancestors. Many Hispanic ranchers feel a connection to the lands once owned by their ancestors.

The scientists in this study wanted to understand the Forest Service's position about the land grants. They were also interested in understanding the Hispanic descendants who want to regain their ancestors' land grants. The scientists wondered if there was a way to **resolve** the conflict between the Hispanic ranchers and the Forest Service's land grant **policy**.



Figure 6. Public lands are often used by individuals and companies to graze sheep and cattle. Photo courtesy of Gila National Forest.

Reflection Section



➔ Describe the problem investigated by the scientists.

➔ State the last sentence in the "Introduction" as a question.

Photo, taken in 1924, courtesy of U.S. Forest Service.



Number Crunch

How many years have passed since the Treaty of Guadalupe Hidalgo was signed in 1848?

Methods

The scientists talked to 300 Hispanic ranchers who lease national forest land to graze cattle and sheep (**figure 7**). These ranchers lease land that their families once owned through land grants. To lease this land, these ranchers pay the Forest Service a fee every year. The scientists asked the ranchers questions about the historic land grants, current land use, and the leases. The scientists entered the answers into a computer. The scientists read the answers and comments and placed them into categories.

The scientists also talked with 10 people who work with the Forest Service. The scientists wanted to know if the Forest Service workers had suggestions that might resolve the conflict.



Figure 7. A federal worker talks with a farmer. Photo courtesy of the Natural Resources Conservation Service.

Reflection Section



- ➔ Why did the scientists talk with Hispanic ranchers as well as with Forest Service workers?
- ➔ Other cultures experienced something similar to this situation in America's past. What other large cultural group in America lost lands on which their ancestors once lived? Where do many of these people live now?

Findings

Some of the Hispanic ranchers said that the past should be left in the past. Most of the ranchers, however, felt anger. They felt anger because the land grants were not being honored by the United States government. Some of them said that by having to lease public land, they struggle to make a living. Others did not want to talk to the scientists about the land grant issue.

Some of the Hispanic ranchers said the United States government was trying to settle some of the land grants. Others said that there may not be a way to resolve the **injustices** of the past. Many people wished the United States government would admit its role in these injustices. Most of the Hispanic ranchers felt their ancestors had been wronged by the United States government.

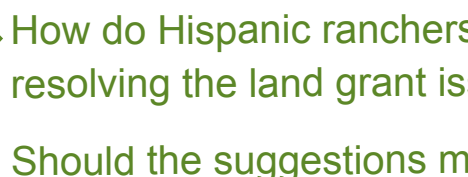
The Forest Service workers told the scientists that they have no choice but to defend the United States government's ownership of public lands. The **official** viewpoint of the government is that the land grants were properly managed following the Mexican-American war. Forest Service workers had different opinions on whether this

was true. Forest Service workers suggested some actions to help resolve the land grant issue:

- Teach Forest Service workers about Hispanic ranchers' history, culture, and way of life.
- Include Hispanic ranchers on committees that plan future use of public lands.
- Develop agreements with Hispanic ranchers about collecting firewood from public lands.
- Develop agreements with Hispanic ranchers about their access to and use of public lands.
- Appoint one Forest Service worker to work directly with Hispanic ranchers.
- Build trust between Hispanic ranchers and Forest Service workers by improving communication.

Forest Service workers did not agree with each other about the land grant issue. All agreed, however, that the issue can only be resolved by the United States Congress. Congress is the body that makes United States laws. Only a new law can change the way Forest Service workers manage the national forests in New Mexico.

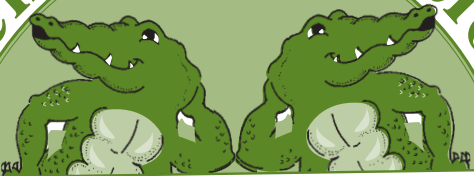
Reflection Section

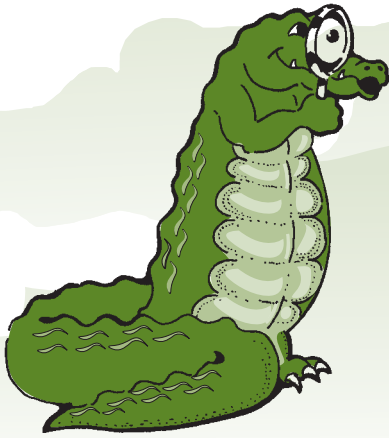
- 
- ➡ How do Hispanic ranchers and Forest Service workers feel about resolving the land grant issue? How do you know?
 - ➡ Should the suggestions made by Forest Service workers be tried? Why?
 - ➡ Have you ever heard people say that better communication will help resolve a problem? Is this true? Why or why not?

Discussion

In the 1960s, Hispanic ranchers began to protest the loss of their ancestors' land grants. Now, in the early 21st century, the question of land grants has not yet been resolved. If the United States Congress considers the question of land grants in northern New Mexico, the issue may finally be resolved. Until then, the Forest Service will continue to manage the lands as national forests for all United States citizens.

Reflection Section

- 
- ➡ Do you think the United States Congress should consider the land grant issue in northern New Mexico? Why or why not?
 - ➡ Many mistakes were made over 100 years ago in places all over the world. Because these mistakes were made before anyone alive today was born, no one living today is responsible. Even so, the descendants of people who were wronged feel the wrongs should be made right. How do you feel about this problem? Hold a class discussion about both sides of this issue. Identify other examples.



Adapted from Raish, C.; McSweeney, A.M. 2008. Land grants and the Forest Service. *Natural Resources Journal*. 48(4):1039-1055. http://www.fs.fed.us/rm/pubs_other/rmrs_2008_raish_c002.pdf.

If you are a Project Learning Tree educator, you may use Activity 32: A Forest of Many Uses, Activity 50: 400-Acre Wood, or Activity 56: We Can Work On It.

Glossary

ancestor (an ses tər): One from whom a person, group, or species comes from.

descendant (di sen dənt): Coming from an ancestor or source.

grassland (gras land): Land on which the most common plants are grasses.

injustice (in jəs təs): An unjust or unfair act.

lease (lēz): Land that someone can use for a set period of time, that usually comes at some cost.

national forest (nash nəl fōr əst): A large area of public land that is forested and taken care of by government. It is available for all people to use and enjoy.

native (nā tiv): Belonging to a particular place by birth.

official (ō fi shəl): The rules of people in a public office.

policy (pā lə sē): A method of action to guide and determine decisions.

public land (pub lik land): Land that is owned by the people as a whole.

regain (re gān): To get back.

resolve (ri zālv): To find an answer or solution.

rural (rūr əl): Something related to the country, country people or life, or agriculture.

scarce (skers): Not plentiful.

Accented syllables are in **bold**. Marks and definitions are from <http://www.merriam-webster.com>.



Photo by Forest Service-Southwestern Region.

FACTivity

Time needed:

One class period

Materials

- “The Lands of Time” *Investi-gator* article

The question you will answer in this FACTivity is:

How is the current situation in the southern African nation of Botswana similar to and different from the historic land grant situation in New Mexico?

The method you will use to answer this question is:

1. First, you will read the following background information:

Botswana is a country located in southern Africa. The Kalahari Desert is located in southern Botswana. For tens of thousands of years, the San Tribes, or Bushman, have lived in the Kalahari Desert. The Kalahari Desert is also home to several Botswana National Game Reserves. The Botswana government wanted the San Tribes to move out of the Kalahari Desert. The government said it wanted the San Tribes to move because the tribes were killing too many animals for food. The San Tribes said the government wanted them to move because diamonds had been discovered underground.

In 2002, the Botswana government moved the San Tribes from the Kalahari Desert into places similar to refugee camps. The San Tribes went to court to win the right to return to the Kalahari Desert. In 2006, the San Tribes won the court case and returned to the desert. The Botswana government then kept the San Tribes from drilling or using any existing water wells. Because the Kalahari is a desert, water is **scarce**. The San Tribes appealed the court ruling that prohibited them from drilling or using water wells. In 2010, a judge upheld the government’s right to prohibit the San Tribes from using or drilling water wells. The San Tribes then appealed to a higher court. On January 27, 2011, an appeals court overturned the earlier ruling. The appeals court said the San Tribes could use existing water wells and drill new water wells.

2. You will use the graphic organizer in the next section. Compare and contrast the situation faced by the ancestors of the Hispanic ranchers in “The Lands of Time” with the experience of the San Tribes. Use the spaces to write what you know about each of these situations. Use complete sentences, proper grammar, and correct punctuation.

	GROUP	
	Hispanic Ranchers	San Tribes
Describe the land area where each group lived.		
Describe the background of the people involved in each situation.		
Which national government was involved in each situation?		
What kind of public land was created out of each group's homelands?		
What happened to cause the government to take each group's land?		
What legal options were available to each group?		
How successful with their legal options was each group? What might be some reasons?		
Write one sentence identifying at least one similarity between these two situations.		
Write one sentence identifying at least one difference between these two situations.		

**Your teacher will lead a class discussion about these two situations.
As a class, discuss what you know about similar situations in history.**



“The Lands of Time” is taken from this saying by David Lawrence Dewey: “Through the sands of time...the written word has changed the course of history, inspired many to fight for their beliefs, and most importantly...elevated mankind to a higher understanding of man’s inhumanity to mankind.” In ancient times, time was measured by an hourglass, through which sand would fall over a specified amount of time (figure 8).

Figure 8. In this hourglass, the sand falls through the small hole in 30 minutes.

Web Resources

Santa Fe National Forest

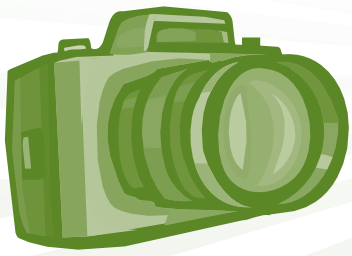
<http://www.fs.usda.gov/santafe/>

Carson National Forest

<http://www.fs.usda.gov/carson>

Historical Events That Affected Northern New Mexico

http://shelledy.mesa.k12.co.us/staff/computerlab/Western_CO_History_Mexican_American_War.htm



Southwestern United States *Investi-gator* Photo Challenge

Explain or write what you see in each photo and how the photo relates to the article in which it was found. If you write, be sure to write at least three sentences for each photo using proper sentence structure, grammar, and punctuation.



Photo by Rod Replogle, Forest Service.



Photo courtesy of Dr. Hugo Magaña.



Photo courtesy of Jim Rorabaugh, U.S. Fish and Wildlife Service.

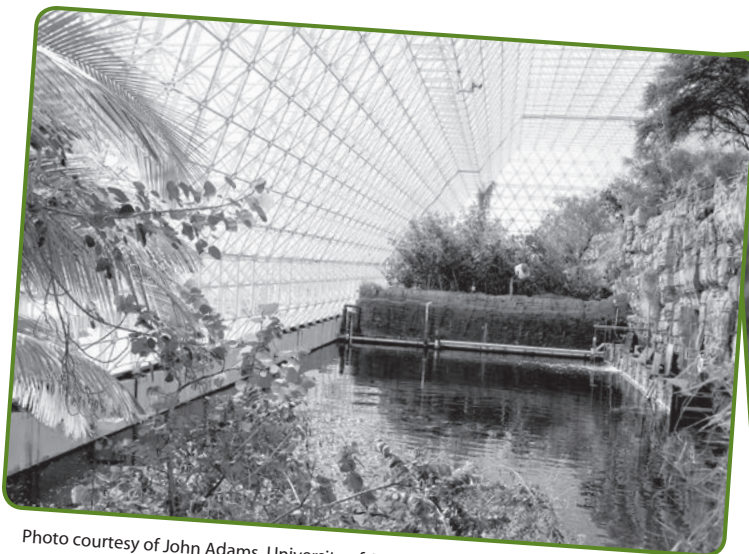


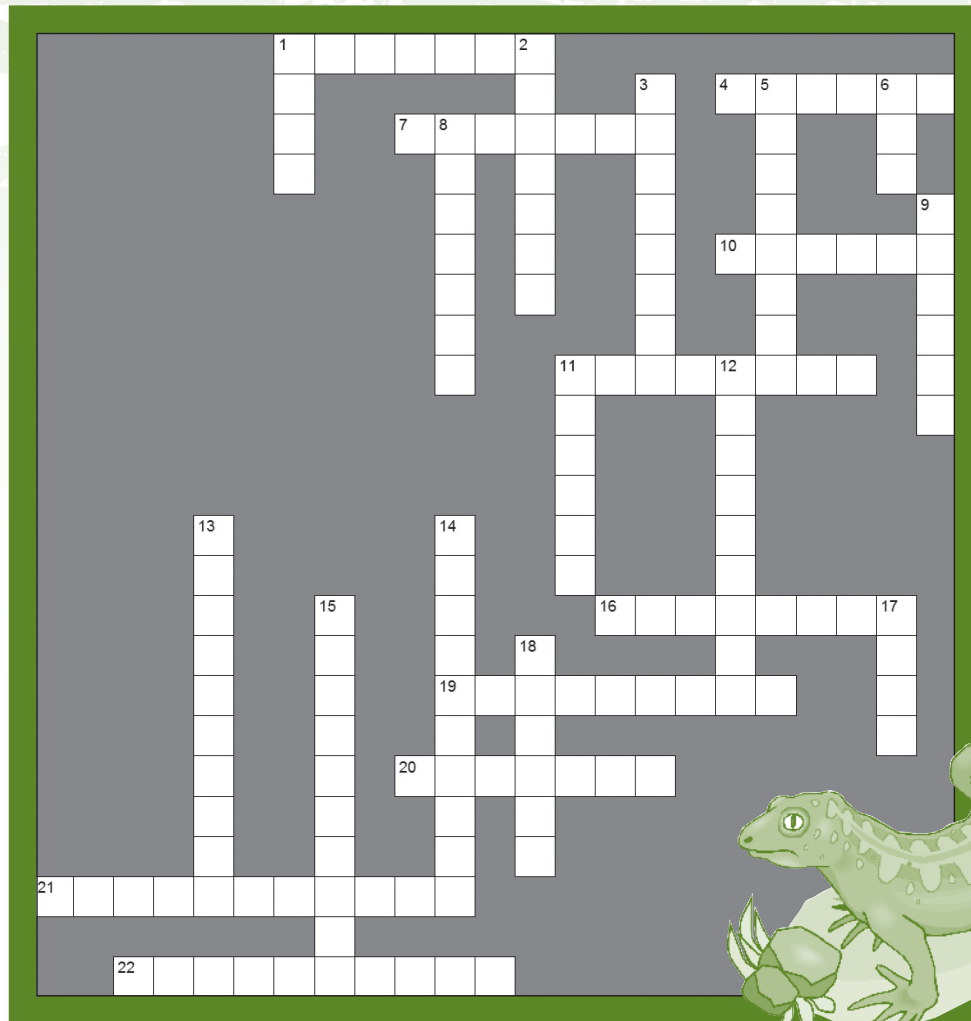
Photo courtesy of John Adams, University of Arizona, Biosphere 2.



Photo by Lisa Lynch, National Park Service.

Southwestern United States *Investi-gator*

CROSSWORD PUZZLE



Across

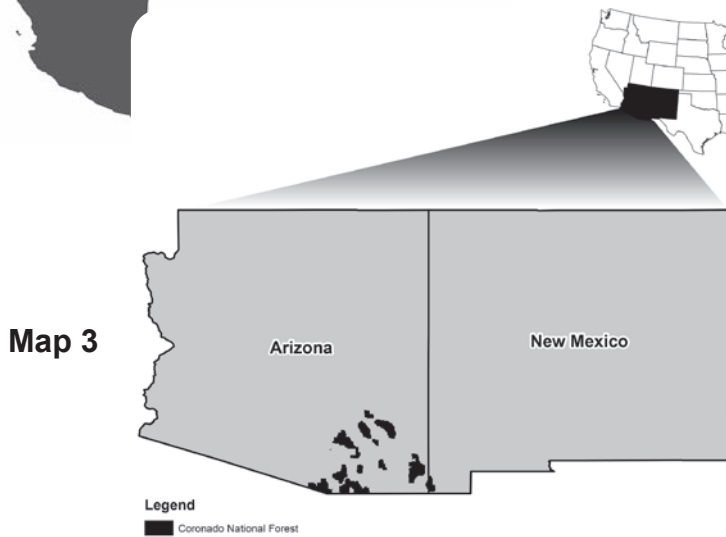
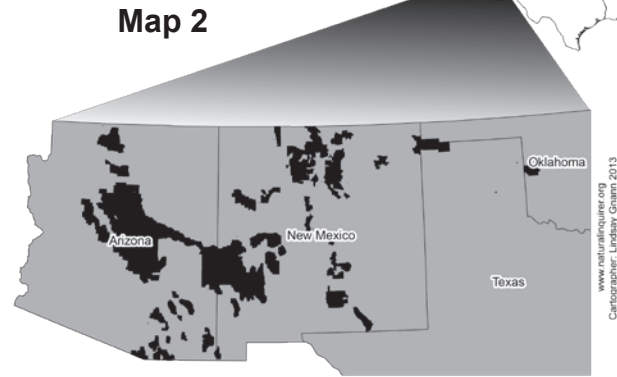
- | | |
|---|--|
| 1. Growing or living in or often found in water. | 19. Community of plant and animal species interacting with one another and with the nonliving environment. |
| 4. Not plentiful. | 20. Environment where a plant or animal naturally grows or lives. |
| 7. A turn or winding of a stream. | 21. Having little resistance. |
| 10. To supply with air. | 22. Coming from an ancestor or source. |
| 11. A substance that plants, animals, and people need to live and grow. | |
| 16. Something that when its quantity is measured, can have a range of different values. | |

Down

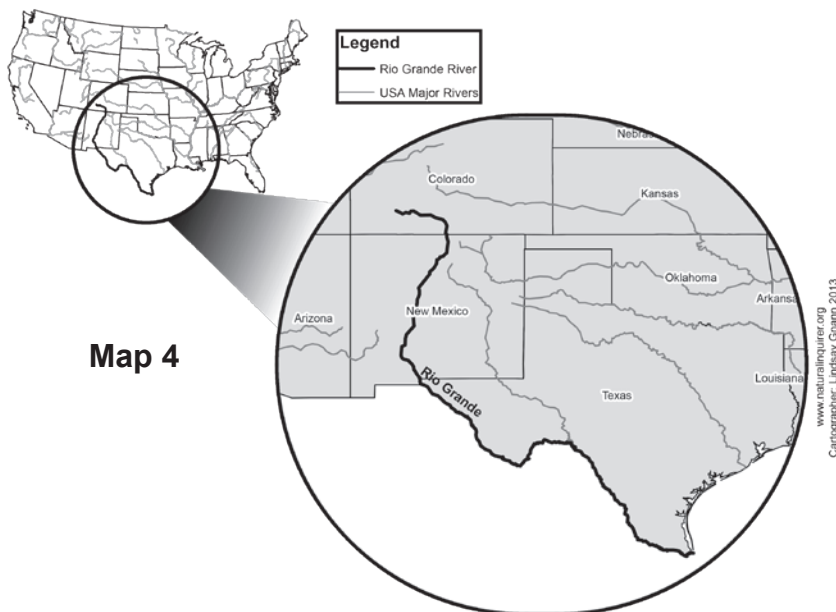
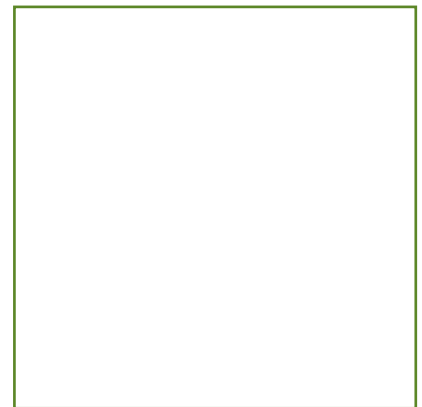
- | | |
|--|--|
| 1. Excessively dry. | 11. Living or growing naturally in a particular region. |
| 2. Part of an experiment that is not being treated with something being tested. It serves as a comparison in the experiment. | 12. An unjust or unfair act. |
| 3. To transfer from one person, animal, or place, to another. | 13. Having a spinal column. |
| 5. To avoid wasteful or destructive use of. | 14. Open to attack or damage. |
| 6. A small, low-lying sandy island formed on the surface of a coral reef. | 15. The process of taking in. |
| 8. No longer existing. | 17. A current of air or water running against the main current or in a circle. |
| 9. To get back. | 18. A method of action to guide and determine decisions. |

Map Activity

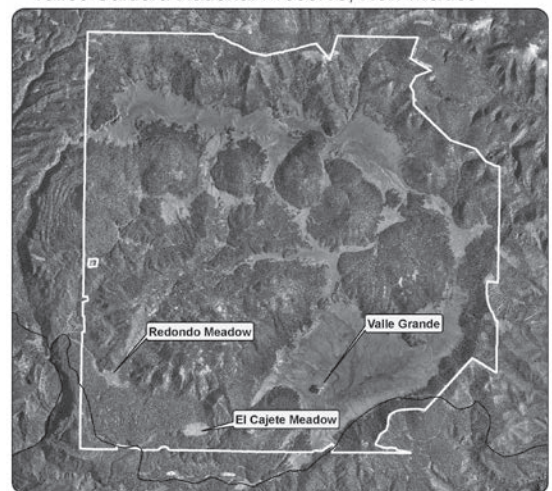
Where Am I in the Southwestern United States?



Your Compass



Valles Caldera National Preserve, New Mexico



Map 5

Five Southwestern maps from this journal are shown on the left. Photos and illustrations found in the articles are shown below. Inside of the box on the left hand page, draw a compass correctly showing the directions of north, south, east, and west. Then, write the map number that matches each photo. A map may match more than one photo.



Map # _____



Photo courtesy of Thinkstock.com.

Map # _____



Photo courtesy of Gila National Forest.

Map # _____



Map # _____



Map # _____

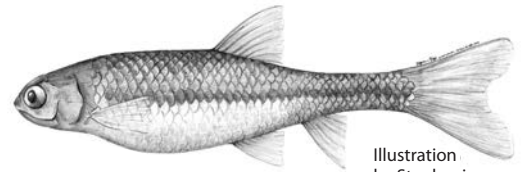


Illustration by Stephanie Pfeiffer.

Map # _____



Map # _____



Map # _____



Map # _____

Using the graphic organizer on the following page, explain the relationship between the photo or illustration and its map. Use complete sentences, proper grammar, and correct punctuation.

Where Am I in the Southwestern United States?

Photo or Illustration	The Relationship Between the Photo or Illustration and the Map is...
Peregrine falcon	
Black-chinned hummingbird	
Cattle	
Flea	
Intermittent stream	
Gunnison's prairie dog	
Rio Grande silvery minnow	
Rio Grande	
Feeding fish	

National Science Education Standards for the Animals and Ecosystems of the Southwestern United States *Investi-gator*

Journal Article	That's a Humdinger!	By the Light of the Silvery Minnow	Wild Ways	Streaming Live	Prairie Dog Days	The Lands of Time
Science as Inquiry						
Abilities Necessary To Do Scientific Inquiry						
Understanding About Scientific Inquiry						
Life Science						
Structure & Function in Living Systems						
Regulation & Behavior						
Populations & Ecosystems						
Diversity & Adaptations of Organisms						
Earth Science						
Structure of Earth System						
Science & Technology						
Understanding About Science & Technology						
Science in Personal & Social Perspectives						
Populations, Resources, and Environments						
Risks & Benefits						
Science & Technology in Society						
History & Nature of Science						
Science as a Human Endeavor						
Nature of Science						
History of Science						

National Curriculum Standards for Social Studies for the Animals and Ecosystems of the Southwestern United States *Investi-gator*

Journal Article	That's a Humdinger!	By the Light of the Silvery Minnow	Wild Ways	Streaming Live	Prairie Dog Days	The Lands of Time
Culture						
Time, Continuity, and Change						
People, Places, and Environments						
Individuals, Groups, and Institutions						
Power, Authority, and Governance						
Science, Technology, and Society						
Global Connections						
Civic Ideals and Practices						





What is the Forest Service?

The Forest Service is a part of the U.S. Department of Agriculture. It is made up of thousands of people who care for the Nation's forest and grassland. The Forest Service manages over 150 national forests and almost 20 national grasslands. These are large areas of trees, streams, and grasslands. National forests are similar in some ways to national parks. Both are public lands, meaning that they are owned by the public and managed for the public's use and benefit. Both national forests and national parks provide clean water and homes

for the animals that live in the wild and places for people to do fun things in the outdoors. National forests also provide resources for people to use, such as trees for lumber, minerals, and plants used for medicines. Some people in the Forest Service are scientists whose work is presented in the journal. Forest Service scientists work to solve problems and provide new information about natural resources so that we can make sure our natural environment is healthy, now and into the future.

For more information, visit <http://www.fs.fed.us>.

What is the Rocky Mountain Research Station?

The Rocky Mountain Research Station is one of five Forest Service Research and Development stations. It maintains 12 research laboratories within its 12-state territory, encompassing the Great Basin, the Southwest, the Rocky Mountains and parts of the Great Plains. The Station employs close to 400 permanent full-time employees, including almost 100 research scientists.

The Station works to provide options on the sustainable use and appreciation of forests and rangelands by producing quality science, quality service, and quality relationships with stakeholders around the Greater Rocky Mountain region.

For more about the Rocky Mountain Research Station visit <http://www.fs.fed.us/rmrs>.

What is the Southwestern Region?

The Southwestern Region of the Forest Service includes 12 national forests and 3 national grasslands in Arizona, New Mexico, western Oklahoma, and the Texas Panhandle. Marked by alpine peaks, colorful mesas, and dramatic canyons, this sunbaked region also features wild whitewater

rivers and clear mountain streams. Renowned for its Indian-Hispanic-Anglo culture, the area's unique heritage is visible in its wealth of prehistoric and historic sites, and in the lives of many of its residents who still celebrate the ways of centuries past.

For more about the Southwestern Region of the Forest Service visit <http://www.fs.usda.gov/r3>.



What Is the Cradle of Forestry in America Interpretive Association?

The Cradle of Forestry in America Interpretive Association (CFAIA) is a 501(c)3 nonprofit organization based in Brevard, North Carolina. CFAIA strives to help people better understand ecology through recreation and education opportunities. Their projects include:

- Campground and recreation area management
- Educational programs and services, including *Natural Inquirer*, *Investi-gator*, and *Nature-Oriented Parenting*
- Sales of forest-related gifts and educational materials
- Workshops, newsletters, and publications
- Partnership with the Forest Service to provide programming at the Cradle of Forestry Historic Site

For more about the CFAIA visit <http://www.cfaia.org>.

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Fall 2013