the Investi-gator

A science journal for elementary school students

Winter 2011

Pacific Northwest Research Station Climate Change Edition

United States Department of Agriculture

Forest Service

International Year of Forests 2011

The *Investi-gator*

Pacific Northwest Research Station, Climate Change Edition Number 2 • Winter 2011

Forest Service scientists highlighted in the journal:

Keith Aubry, Pacific Northwest Research Station

Rick Edwards, Pacific Northwest Research Station

Kevin McKelvey, Rocky Mountain Research Station

Ron Neilson, Pacific Northwest Research Station

Deanna Olson, Pacific Northwest Research Station

Other scientists highlighted in this journal:

Jason Fellman, University of Alaska Southeast

Jóse Fragoso, Stanford University

Peter Hernes, University of California Davis

Eran Hood, University of Alaska Southeast

Terry Root, Stanford University

Durelle Scott, Virginia Tech

Rob Spencer, Woods Hole Research Center

Ken Thompson, University of Sheffield

Published by the Pacific Northwest Research Station

Photo credits for cover: Brome McCreary (spring peeper), Ken Curtis (wolverine), Steve Baskauf (fruit), Durelle Scott (glacier).

With thanks to

Rachel Small, Cradle of Forestry Interpretive Association

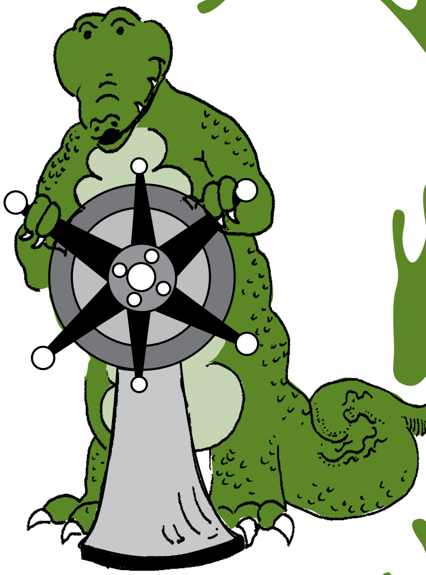
Michelle Andrews, University of Georgia

Emily Melear Daniels, Cradle of Forestry Interpretive Association

Editorial Review Board

Felida Elementary School, Vancouver, Washington,
Mrs. Beaman's 5th Grade Class

Table of Contents

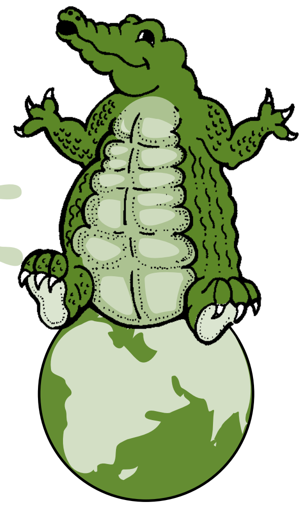


Features

About the *Investi-gator*

The *Investi-gator* is the newest member of the *Natural Inquirer* family. The *Natural Inquirer*, for middle school students, and the *Investi-gator*, for upper elementary level 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 the *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 wants to solve or answer.

Method
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 after 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 you will find 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:**
  You must be interested in learning.
- **Be careful:**
  You must be accurate in everything you do.
- **Be open-minded:**
  You must be willing to listen to new ideas.
- **Be enthusiastic:**
  You must be interested in a particular topic.
- **Question everything:**
  You must think about what you read and observe.

Welcome to the Climate Change *Investi-gator*!

Is the climate changing over time? In the past few years, most scientists have agreed on at least one thing about climate change. They have agreed that changes in Earth's climate over the past 100 or more years point to a warming of Earth's surface. This warming is greater than they would have expected from normal cycles.

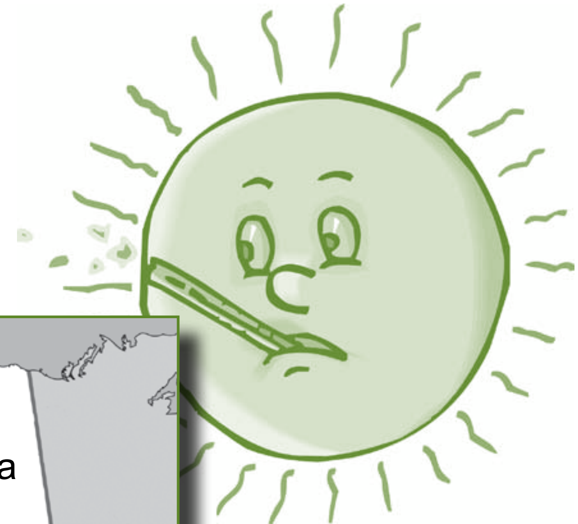
The average temperature of Earth depends on two things. First, the temperature depends on how much of the sun's energy comes through the atmosphere to Earth's surface. Second, the temperature depends on how much energy escapes back into space. About 90 percent of the sun's energy is trapped by gases in the atmosphere! This energy is sent back to Earth in all directions. This energy warms the planet. This is called the greenhouse effect. The gases are called greenhouse gases. Without these gases, humans and other forms of life could not survive on Earth.

Over the last 150 years, however, the amount of greenhouse gases in the atmosphere has risen sharply. The sharp rise in greenhouse gases is believed to be caused by an increase in the burning of fossil fuels. Examples of fossil fuels are oil, coal, and natural gas. These higher levels of greenhouse gases in the atmosphere trap more of the sun's heat. This leads to increasing temperatures on Earth.

Evidence from scientific measurements gives scientists more confidence in their conclusions about global climate change. Yearly global temperatures have been rising, the amount of Arctic sea ice has been shrinking, and glaciers are getting smaller. Scientists are now able to use computer programs for help. These computer programs track and predict changes in the atmosphere and oceans across the globe.

Global climate change is sometimes called global warming. Scientists use the term "global climate change" because many aspects of Earth's climate are changing. Along with rising yearly temperatures, scientists predict increases in both droughts and flooding. The effects of climate change will be different in different places on Earth. Some places will experience periods of heavy rain, for example, and others will experience periods of low rainfall.

Because of climate change, scientists and forest managers have had to think in new ways about our natural resources. While we work to reduce the amount of fossil fuels we burn, we also must work with the coming changes. Here are some of the new ways scientists and forest managers are thinking:



1. **Instead of fighting change, work with it. Do what we can to reduce the impact of climate change, but be prepared for change and adapt as needed.**

2. **Understand that we do not know exactly what will happen in the future, but we do the best job we can with prediction. Sometimes, we will make a decision about what to do, and later we may have to make a different decision.**

3. **Accept that the way we did things in the past may not be the right choice for the future.**

4. **Focus on the way forests and other natural systems work, instead of what they look like.**

The Pacific Northwest region of the United States.

Climate change will bring challenges for everyone. However, climate change is also helping us to think in new ways and to do some things differently. In this *Investi-gator,* you will find research that focuses on the Pacific Northwest region of the United States. The scientists in this region have been studying how climate change may be affecting different animals, plants, and ecosystems.

In this journal, you will read about four topics. In “Amphibious Assault” you will learn how frog and toad breeding patterns might respond to climate change. The article “Seed Ya Later!” examines how plants may move in a changing climate. In “There’s Snow Place Like Home” you will learn how climate change may affect wolverines. Finally, in the article “Frozen Food,” you will learn how water from melting glaciers may provide food for animals living in nearby bays and rivers. Forest Service scientists have been a part of the research in these articles. You can learn more about the Forest Service by reading the inside back cover of this journal or by visiting **http://www.scienceinvestigator.org**.

Amphibious Assault:

How Climate Change May Affect Amphibian Breeding

Meet the Scientists!

Dr. Olson, research ecologist (ē köl ə jist):

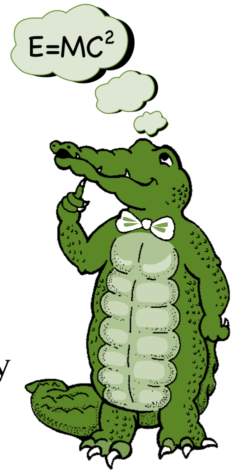
Finding my first breeding group of western toads in the Oregon Cascade Mountain Range is one of my all-time best moments. I had been hunting for toads for hours along a lake shoreline and was about ready to give up. Then, I realized I had been hearing a soft noise coming from out in the deeper water. I went closer and there were scores of breeding toads clustered in a very small area in some submerged shrubs. I later realized that I was incredibly lucky to have found the "needle in that haystack" that day!

What does the term "needle in a haystack" mean? What did Dr. Olson mean when she said that she found the needle in the haystack?

Dr. Root, ecologist:

My favorite science experience was in 1995 when I was at a meeting. A person speaking before me put up a graph that looked just like one of mine — with years on the x-axis and day-of-arrival on the y-axis. The plot showed the tree was blooming earlier in the spring. My graph was for birds arriving earlier in the spring on migration. The other person's study was in Europe and mine was in the US. Could it be that global warming was causing different types of species in different parts of the globe to change in similar manners? The answer was yes.

Thinking About Science

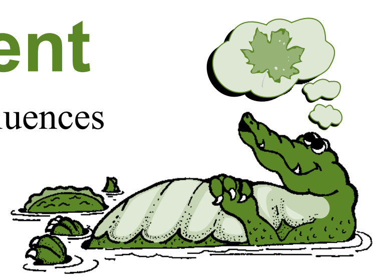


Often scientists need to look at something over a period of time in order to understand what is really happening. The scientists in this study had information about frog breeding over many years. In some cases, they had information for 15 years in a row.

When scientists are able to gather information over several years, it can give them a better idea of what is happening. For example, think about a year in school where you did not do your best work. Then you had several years where you did excellent work. You would want people to look at all your years of work rather than just the one year where your work was not as good.

In the same way, scientists get a much clearer idea of what is happening when they have several years of information to review and study. In this study, the scientists were interested in **climate** change and **amphibians**. You will learn about both of these in the next section.

Thinking About the Environment



Climate change influences many different things. Climate is the average condition of the weather (rainfall, temperatures, etc.) over large areas, over a long time, or both. When the climate changes, it affects animals and plants in different ways. Scientists believe that Earth's climate is getting warmer. As the climate becomes warmer, scientists have found that the number of plants and animals changes. The places where these plants and animals live change too. The scientists in this study wanted to study the effect of a changing climate on one type of animal, the amphibians.

Amphibians live part of their lives in the water and part of their lives on land. They are **vertebrates** or animals that have a backbone **(figure 1)**. They are **cold-blooded**, which means their temperature depends on their environment. Some amphibians you might be familiar with are frogs and toads. What is another type of amphibian?

Figure 1. Amphibians have a backbone and are cold-blooded.

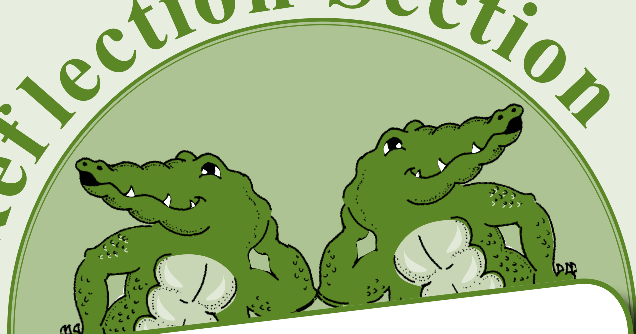
Introduction

Scientists have found that some plants and animals may be affected by a warmer climate. Butterflies, reptiles, birds, insects, and amphibians all seem to be affected by climate change. Climate change can change the **breeding patterns** of some animals. Breeding patterns refer to when and how animals reproduce, including how many young an animal has and how often.

Scientists were particularly concerned about amphibians because some amphibian populations are declining. Amphibians may be more susceptible to climate change because they are cold-blooded animals. For a reminder of what cold-blooded means, reread the "Thinking About the Environment" section.

If breeding patterns change, an entire population may change or become **extinct**. The question the scientists in this study wanted to answer was how certain amphibian populations and their breeding patterns may be responding to climate change.

Reflection Section



- What is the problem the scientists wanted to answer in this study?
- Why might cold-blooded animals be more quickly affected by climate change than warm-blooded animals?

Pronunciation Guide

ā	as in ape	ū	as in use
a	as in car	u	as in fur
ē	as in me	ü	as in tool
i	as in ice	ŋ	as in sing
ō	as in go	ə	as in about (both a and u)
oi	as in for		

Accented syllables are in **bold**.

Glossary

Amphibian (am **fib** ē ən): Animals that live part of their life in the water and part of their life on land.

Breeding pattern (**brē** diŋ **pat** ərn): When and how animals reproduce, including how many young an animal has and how often.

Climate (**klī** mət): The average condition of the weather (rainfall, temperatures, etc.) over large areas, over a long time, or both.

Cold-blooded (kōld **bləd** ed): A characteristic of an animal whose body temperature depends on their environment.

Extinct (ek **stiŋ(k)t**): No longer living.

Vertebrate (**vər** tə brət): Animals that have a backbone.

Accented syllables are in **bold.**

Method

The scientists chose three places in North America where they had information available about amphibians over several years. They had information about amphibians in Oregon, Ontario, and Michigan **(figure 2)**. They chose to study frogs and toads in these areas **(figures 3–7)**.

The scientists were interested in the effect of climate change on amphibian breeding. Therefore, the scientists had to find out certain information. They had to

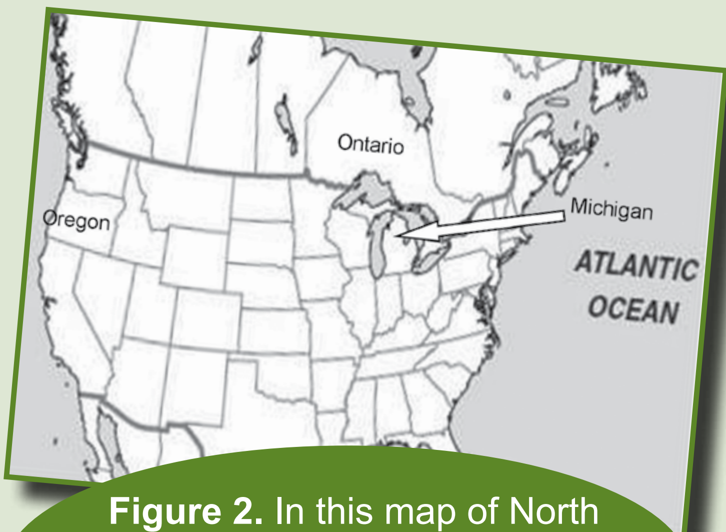


Figure 2. In this map of North America, you can see the location of the three areas scientists studied frogs and toads.

Figure 4. Cascades frog.

Figure 5. Western toad.

Where	Frog or toad studied	Scientific name of amphibian the scientist studied	Time period studied
Oregon	Cascades frog Western toad	*Rana cascadae* *Bufo boreas*	1982–1999
Ontario	Fowler's toad	*Bufo fowleri*	1980–1981, 1988–1998
Michigan	Spring peeper	*Pseudacris crucifer*	1967–1994 (not 1988)

Figure 3. Information about the frogs and toads that were studied.

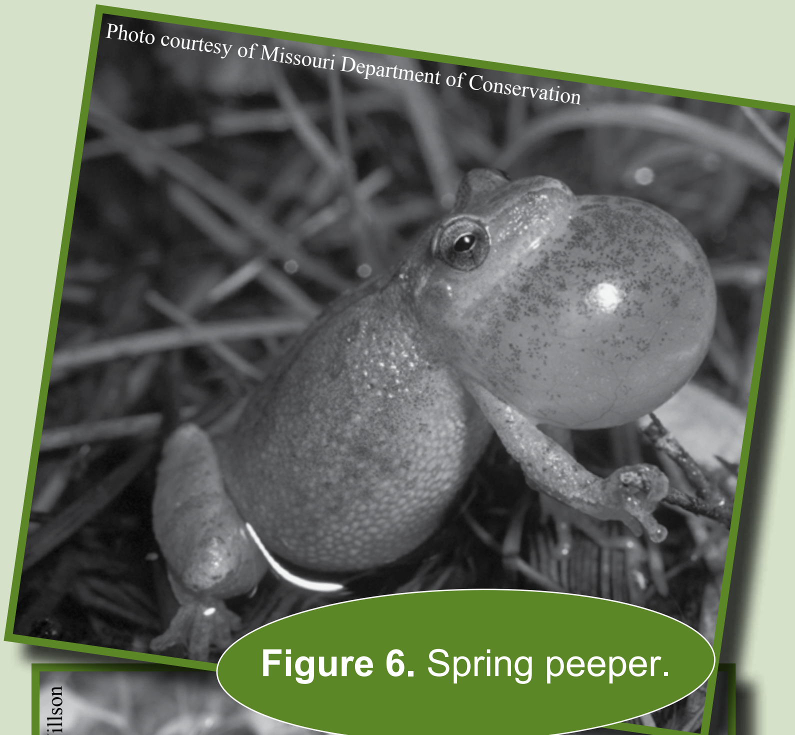


Figure 6. Spring peeper.

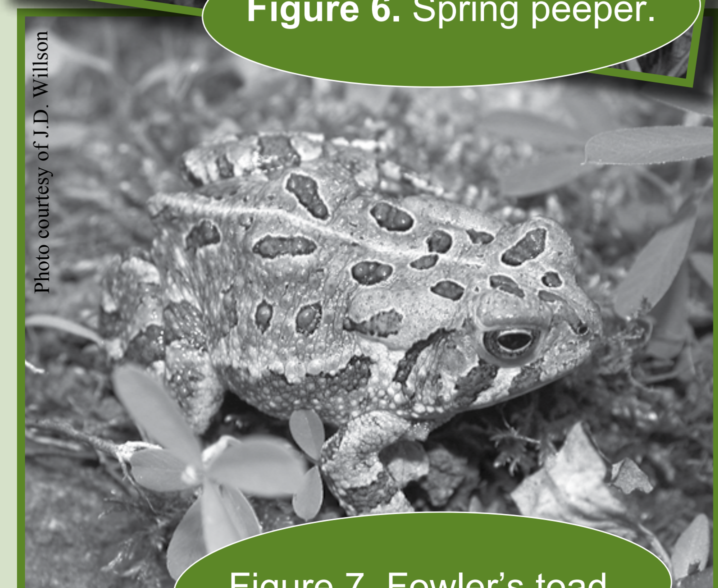


Figure 7. Fowler's toad.

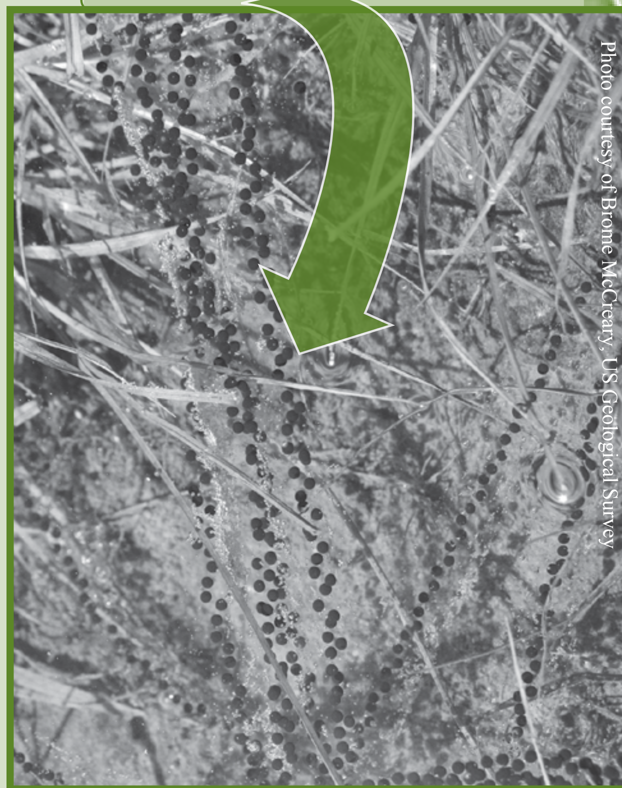


Figure 8a. Egg masses.

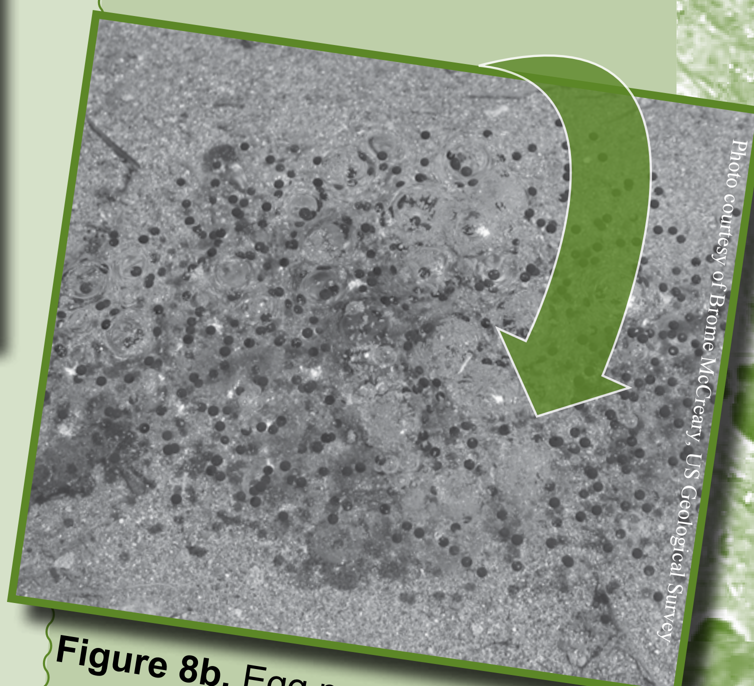


Figure 8b. Egg masses.

discover the first day of breeding season for each frog or toad over a period of years. For the Cascades frog and western toad, the scientists used the presence of egg masses as the first day of breeding **(figures 8a and 8b)**.

Some amphibians have a call that they make when they are ready to breed. For the spring peeper and Fowler's toad, the scientists used the first date of calling as the beginning of breeding season. The scientists also had to figure out the daily air temperature for the 3 months before breeding season. With all of this information, the scientists could figure out if climate change might have an effect on amphibian breeding patterns.

- Why do you think the scientists chose to study frogs and toads in three different areas?
- Why do you think the scientists wanted to know what the daily air temperature was in the 3 months before breeding season?

Findings

The scientists found that one type of amphibian was breeding earlier **(figure 9)**. The scientists found that other amphibians were not breeding earlier.

Frog or toad	Breeding earlier?
Western toad	Yes at one site, no at four other sites
Cascades frog	No
Spring peeper	No
Fowler's toad	No

Figure 9. Frog and toad breeding patterns.

- Based on the scientists' findings, does it look like climate change is having an effect on when the amphibians breed?
- Look at the findings for the western toad. Why do you think it is important to test at different sites?
- Look at the time periods studied in figure 3. What is one possible explanation for why the frogs and toads were not found to be breeding earlier?

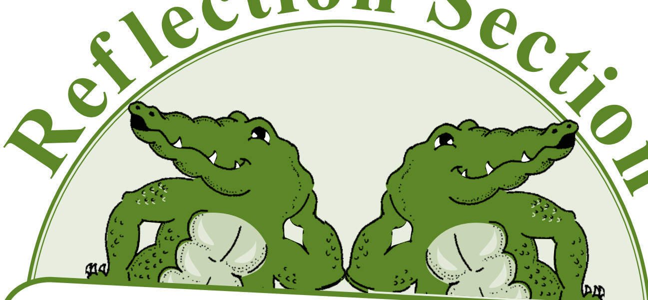
Discussion

The breeding patterns did not show much change for several of the amphibians that the scientists studied. Scientists are not sure why the breeding patterns are changing for some but not for others. There are many reasons why amphibians may be sensitive to climate change. For example, amphibians are cold-blooded so they may be especially sensitive to changes in temperature. Changes in precipitation because of climate change could also affect the amphibians, but that was not the focus of this particular study.

There have been other scientific studies that have shown that amphibians are being affected by climate change in various ways. However, based on the findings of the scientists in this study, the scientists think it is too early to say that climate change is affecting the timing of amphibian breeding in North America.

The scientists believe that more studies need to be done over longer periods of time. These studies also need to be conducted across more species and at more locations. After these additional studies, scientists can begin to draw conclusions about how climate change is affecting amphibian breeding patterns. Data gathered from this study will be good for comparisons of future breeding patterns.

Reflection Section



- Why would amphibians be particularly sensitive to changes in temperature?
- Do you agree with the scientists that more studies should be done? Why or why not?

This article was adapted from Blaustein, A.R.; Belden, L.K.; Olson, D.H.; Green, D.M.; Root, T.L.; Kiesecker, J.M. 2001. Amphibian breeding and climate change. Conservation Biology. 15(6): 1804–1809.

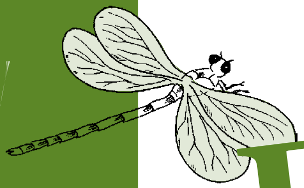
Frog and Toad Fun Facts

Spring peeper—Spring peepers can allow most of their bodies to freeze during winter hibernation and still survive. **http://animals.nationalgeographic.com/animals/amphibians/spring-peeper/**

Western toad—Western toads are poisonous! They have enlarged glands (called parotid glands) behind each eye. These glands secrete a white poison that ends up inside the mouth of any predator who tries to munch a toad. **http://www.blm.gov/id/st/en/prog/wildlife/amphibians/frogs_and_toads/western_toad_.html**

Cascades frog—Cascades frogs have gold eyes and are named for their traditional homeland the Cascade Mountains. **http://www.dfw.state.or.us/conservationstrategy/frogs.asp**

Fowler's toad—When handled roughly, Fowler's toad feigns death and plays "possum." It may lay on its back with legs curved upward and may remain motionless for several seconds until the threat has passed. **http://www.cmnh.org/site/ResearchandCollections/VertebrateZoology/Research/FamilyBufonidae/FowlersToad.aspx**



FACTivity

Time needed: Three or four class periods

The question you will answer in this FACTivity is:

How are human life and frog life similar, and how are they different?

Materials

- Paper
- Pencils
- Crayons or markers for illustrations

The process you will use to answer the question for this FACTivity is:

During the first class period (and perhaps into the second class period):

1. Students will break into pairs and write a story about a person who turns into a frog.

2. Students will consider the following questions as they write.

- What would the person do as a frog?
- How would they survive?
- What stages of the life cycle would they experience?
- What would winter be like?

3. Now reverse the situation and have a frog turn into a person.

- What is life like now?
- How might the human world be challenging for the frog person?
- What would the frog person miss from its former life?
- What would the frog person really enjoy?

In the third and fourth class period:

4. Once the students have written both stories, have them create a reversible booklet. On the right side of the booklet, students should write and illustrate their first story about a person turning into a frog. They should only use the right side of every page. Then they should flip the booklet over and write the other story going in the opposite direction. Don't forget to add drawings.

5. Students can share their stories with classmates.

Extension: If you have a kindergarten reading buddy or a younger class that your students read with, they can share their frog stories with them.

Here are some additional resources that you may use when completing this FACTivity.

The Frog Prince
by the Brothers Grimm

The Frog Prince Continued
by Jon Scieszka and Steve Johnson

The Frog
an Italian tale

Frog and Toad Are Friends
by Arnold Lobel

The Celebrated Jumping Frog of Calaveras County
by Mark Twain

The Frog Who Became an Emperor
a Chinese Fable

Aesop's Fables

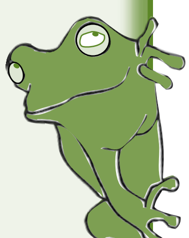
"The Frog and the Ox"

"The Frogs and the Well"

"The Frog's Complaint Against the Sun"

"The Frogs Asking for a King"

"The Frogs Desiring a King"



This activity is adapted from the Center for Global Environmental Education
http://cgee.hamline.edu/frogs/teachers/activity/magic.html

If you are a trained Project WILD educator, you may use the activity "Stormy Weather" on page 85, asking students to visualize themselves as a frog or toad.

National Science Education Standards addressed in this article:

Science as Inquiry: Abilities to do scientific inquiry, Understandings about scientific inquiry

Life Science: Reproduction and heredity, Regulation and behavior, Populations and ecosystems, Diversity and adaptation of organisms

Earth Science: Structure of the Earth system

Science in Personal and Social Perspectives: Natural hazards, Risks and benefits, Science and technology in society

Science and Technology: Understandings about science and technology

History and Nature of Science: Science as a human endeavor, Nature of science

---

Additional Web Resources

National Geographic's spring peeper information
http://animals.nationalgeographic.com/animals/amphibians/spring-peeper.html

Cascades frog habitat map
http://depts.washington.edu/natmap/maps/wa/amphibians/WA_cascades_frog.html

Animal Diversity Web's information on Fowler's toad
http://animaldiversity.ummz.umich.edu/site/accounts/information/Bufo_fowleri.html

USGS western toad information
http://www.npwrc.usgs.gov/resource/herps/amphibid/species/bboreas.htm

Seed Ya Later!

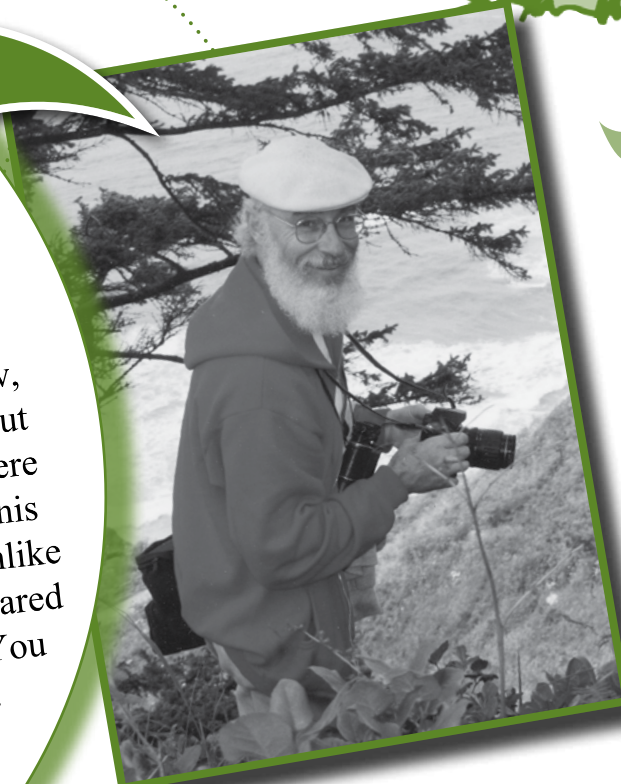
Predicting the Movement of Trees in a Changing Climate

Meet the Scientists!

Dr. Neilson
bioclimatologist
(**bī** ō **klī** mə **tə** ō jist):

I became a bioclimatologist because I like to be in the woods. Bioclimatologists study the relationship of living things to their climate. Climate is the average weather of an area over a long period of time. This can be months, years, or hundreds of years. As a young scientist, I began to compare different plants with their climate. I asked this question: How do different kinds of plants grow, reproduce, and die, while living where they do? After about 15 years, I began to build models to better understand where plants live. Models are representations of something. In this case, my models were built on a computer. My models, unlike model cars or airplanes, were built from numbers. I compared different kinds of plants with the climate of their area. You will learn about these kinds of models in this article.

By building computer models, I can better understand and predict what might happen to plants as their climate changes. It is great to be able to spend my time learning about the woods!



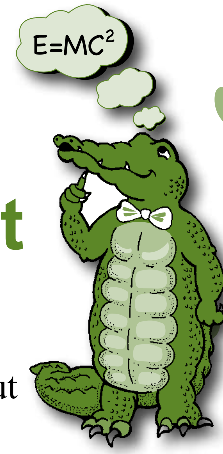
Dr. Fragoso, ecologist (ē **kə** lō jist):

As an ecologist, I study the relationships of living things with each other and with their environment. One of my favorite science experiences was flying my ultralight airplane over the Amazon rain forest. While flying, I learned to identify trees from the air. I also learned how the animals I radio-tracked moved over many miles from one patch of trees to another.

Dr. Thompson,
plant ecologist:

I'm very interested in the wildlife of gardens. My favorite project was one that showed just how much wildlife lives in a typical private garden. For me, however, the best moment in science is when you show that what everyone believes to be true is actually wrong!

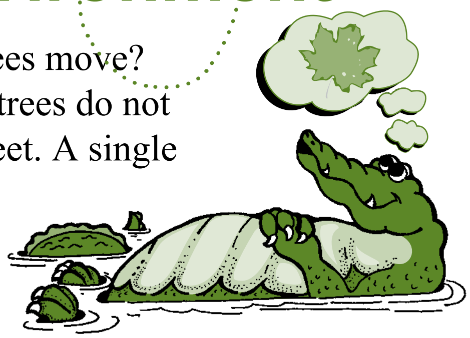
Thinking About Science



You probably hear a lot about scientific models. Scientists use models to examine how systems look and behave. In your school, you may have a model of the solar system. This model shows how the planets revolve around the sun. This is a model of the relationship of the planets to each other and to the sun. Scientists also use mathematics to create models. These models use numbers to represent real or possible relationships.

In this research, the scientists wanted to improve their models. Their models showed where on Earth different kinds of trees might grow. As the climate changes, the places different trees can grow will change. The scientists were interested in how and where different types of trees might grow as the climate changes. They wanted the models to show how the seeds of trees move away from the parent tree. If they could include how seeds move, this would improve their models. They could do a better job of predicting where different types of trees might grow in the future.

Thinking About the Environment



How do trees move? You know that trees do not have legs and feet. A single tree cannot move to a new location. Trees use a different process to move. Trees move through their seeds. By having its seeds move away, a type of tree can move to a new location.

Seeds move away from the parent tree in four ways. First, wind can blow the seeds away. Second, water can move the seeds downstream. Third, animals can carry seeds to new places. They do this when they eat seeds and later poop away from the tree. Animals can also carry seeds in their fur or they carry seeds in their mouth and drop them by mistake. Fourth, people can move seeds. Seeds, for example, can get stuck in car tires or on clothing.

Scientists have words to describe how far seeds move away from the parent tree. When a seed does not move far away from its parent tree, scientists say it has stepped from the tree. When a seed moves far away from its parent tree, scientists say it has jumped away from the tree.

Introduction

Scientists use models to predict what might happen in the future. Some scientists would like to predict the movement of trees as they respond to a changing climate. The scientists knew in what kind of areas different kinds of trees like to grow. They knew what temperatures different types of trees must have to grow **(figures 1a, 1b, and 1c)**. The models needed improvement, however, because they did not include the different ways and rates that plants move. The scientists in this study wanted to answer this question: What is the best way to include the movement of tree seeds into their models?

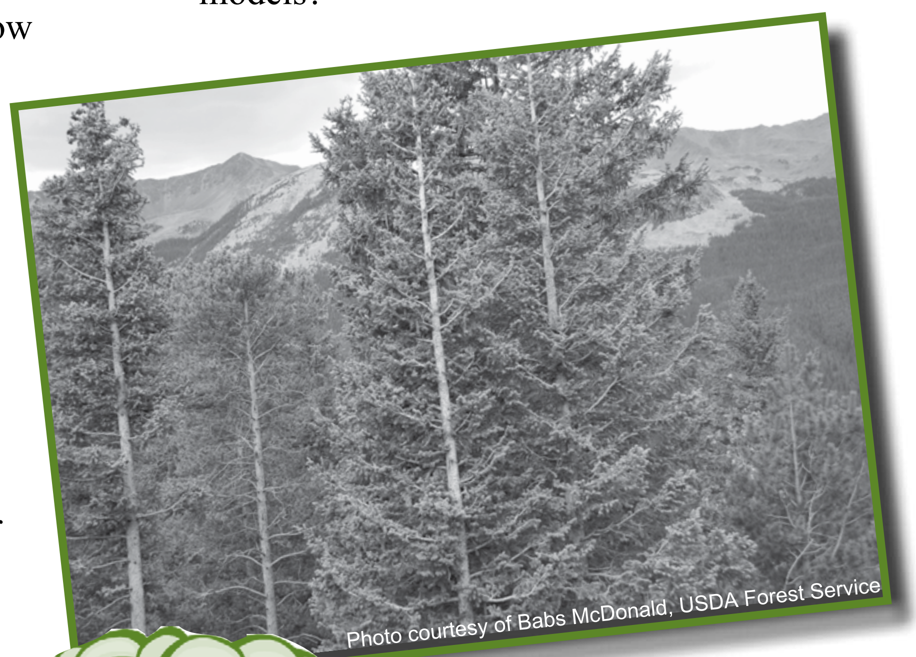
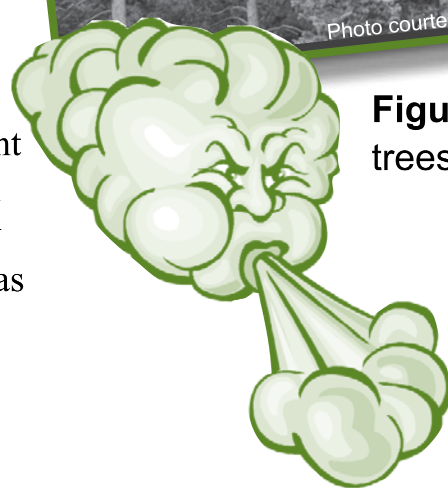


Figure 1a. Boreal (**bör** ē əl) trees grow in cold climates.



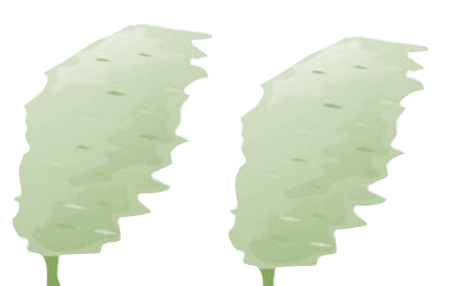
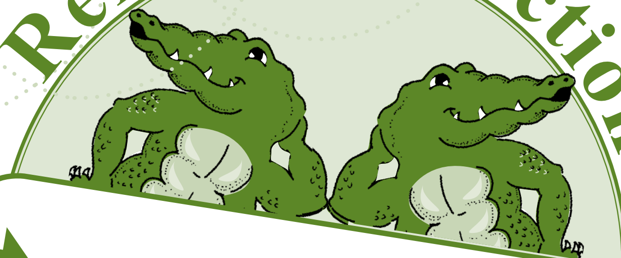


Figure 1b. Palm trees grow where it is warm all year.



Reflection Section

- How does a tree move to a new location?
- Why do you think the scientists in this study wanted to include the movement of tree seeds into their models? (Hint: Reread the first two sentences in the "Introduction.")

Figure 1c. Oak trees grow in both warm and cool climates.

Method

The scientists identified what information they needed about how trees move. They collected information about how seeds move **(figure 2)**. They learned not only how seeds move, but how far they can move **(figure 3)**. The scientists also collected information about how trees grow in new areas **(figure 4)**. They examined how this information could be included in their models.

The scientists identified whether a seed was more likely to step or jump to a new area. They also considered how long it would take the different types of trees to grow in a new area. They put all of this information into one of their computer models.

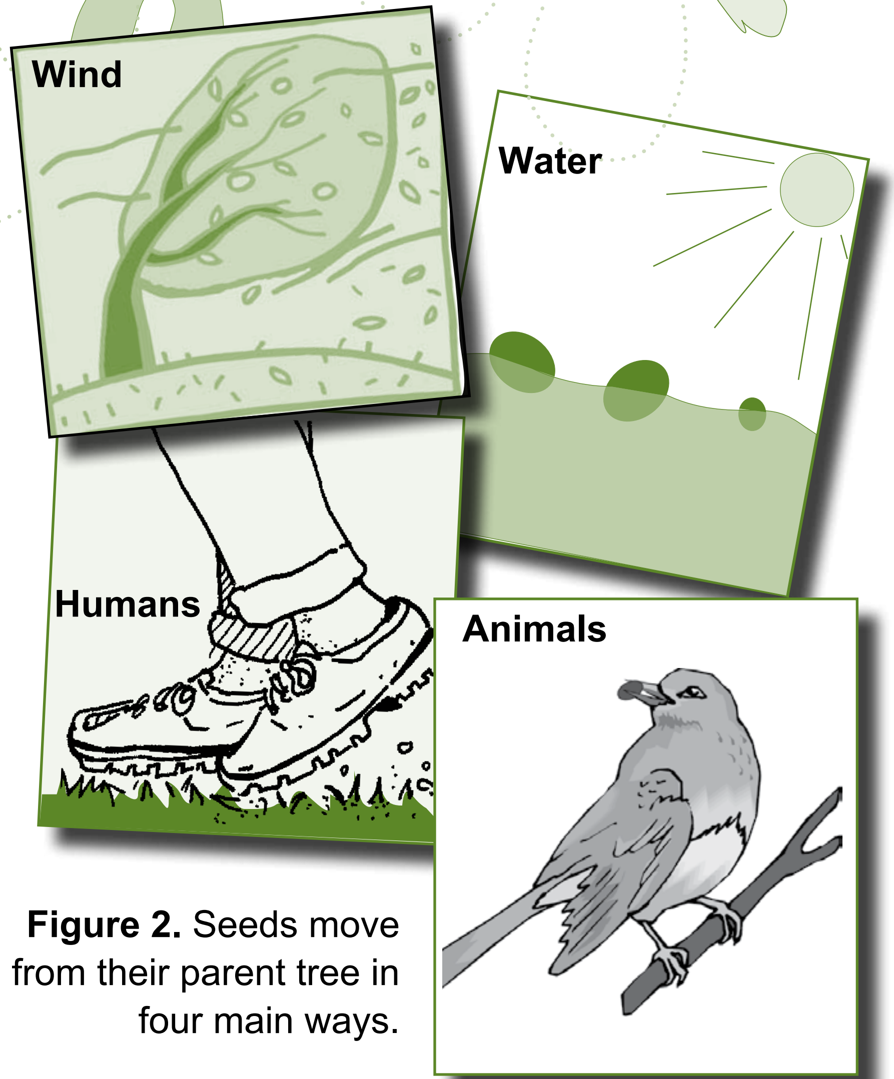


Figure 2. Seeds move from their parent tree in four main ways.

Figure 3. Seeds either “step” or “jump” away from their parent tree.

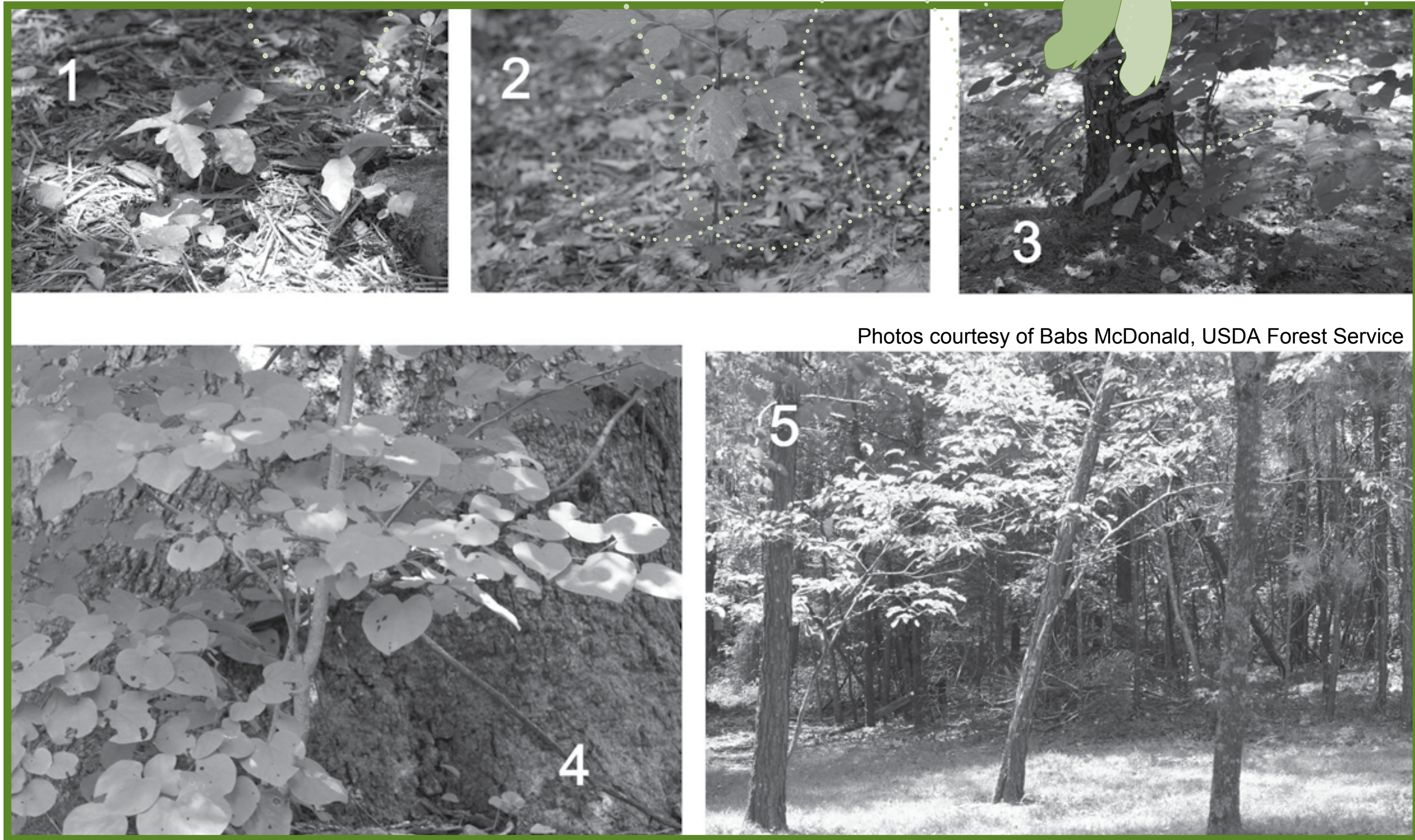
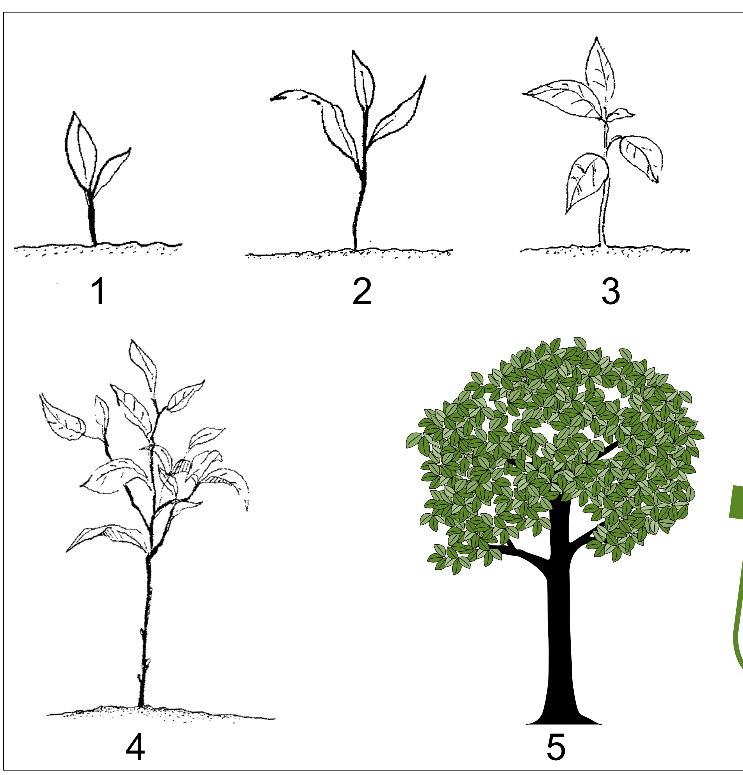
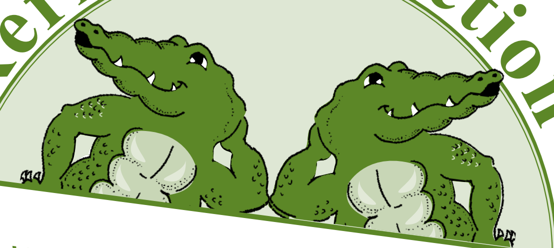


Figure 4. Seedlings need time to become established as healthy trees. Although these photos show different species of trees, you can see how a tree grows from a seedling (no. 1) to an established tree (no. 5). A tree can take 5 or more years to become established.



Reflection Section



- Why is it important for the scientists to know how far and how fast seeds can move?
- Why was it important to know which tree seeds step and which ones jump?

Findings

The scientists placed different types of trees in categories by how their seeds were most likely to move. For example, maple, ash, and elm seeds have wings and are most likely to be blown by the wind **(figure 5)**. Oak trees have acorns that would most likely be moved by squirrels and other animals **(figure 6)**. Birds may carry seeds and drop them by mistake.

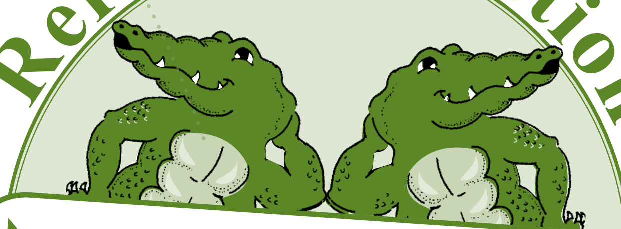
The scientists found that it was easier to predict the movement of some trees over others. Wind direction and speed are easier to predict than the movement of people and animals. The scientists found that they could better predict the movement of trees that have wind-blown seeds.

The scientists believe that the climate might change too fast for some trees to successfully move to new areas. As the climate changes, other types of trees will come in and take the old trees' places. If the trees cannot successfully move to new areas, they might not survive.

Figure 5. Winged seeds are most likely to move by being blown.

Figure 6. Animals may carry seeds away from their parent tree. How do you think this seed travels with an animal?

Reflection Section

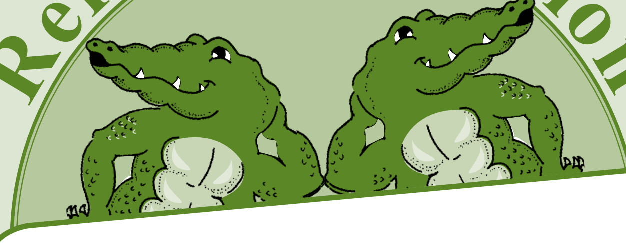


- As the climate warms, do you think different types of trees will be more likely to move north or south? Why?
- The scientists found that it was easier to predict the movement of trees with wind-blown seeds. Do you think it was also easier to predict the movement of trees whose seeds can float downstream? Why or Why not?

Discussion

As the climate changes, the distance and speed of tree movement will affect how well a type of tree can survive. To better understand and predict the future, scientists need to include the movement of seeds in their models. Some types of trees will be able to move as the climate changes. Others will not be able to move successfully. If some trees cannot move successfully, other types of trees will likely take their place.

Reflection Section



- If a type of tree is able to successfully move to a new location, what else might move with it?
- Could the types of trees growing near your home change over the next 100 years? Why or why not?

FACTivity

The questions you will answer in this FACTivity are:

What are the different ways that seeds move?

How can models help us better understand how something happens?

Time needed: Two class periods (possibly more if you want students to create a model rather than draw one).

Materials

- Six pieces of 8 ½ x 11 paper to make cards
- Pictures of fruit and seeds (p. 27)
- Blank paper for students to draw models
- Materials to create models (such as leaves, grass, twigs, art supplies, etc., optional)

The method the class will use to answer this question is:

1. First, the teacher will introduce the different ways that seeds can move. An 8 ½ x 11 card can be made with each of the following titles:
   a. **Wind**
   b. **Water**
   c. **Animals**
   d. **Explosive** (The fruit "explodes" sending the seed a small distance from the tree.)
   e. **Bounce or roll**
   f. **Humans**

Discuss each of these briefly as you hold up each card.

2. In small groups, students will look at the figures accompanying this FACTivity. Students will discuss each picture and figure out how the seeds are moving. Each small group will make a list. After 5 minutes, each group will take a type of seed and tell the class how it moves away from its parent tree. For answers to this activity, please visit our Web site at www.scienceinvestigator.org and click on educator resources.

3. Once students have completed this part of the activity, they will draw or create a model of what it might look like as the seed moves. These models can be displayed in the classroom.

Adapted from Neilson, R.P.; Pitelka, L.F.; Solomon, A.M.; Nathan, R.; Midgley, G.F.; Gragoso, J.M.V.; Lischke, H.; Thompson, K. 2005. Forecasting regional to global plant migration in response to climate change. BioScience. 55(9): 749–759.

If you are a Project Learning Tree-trained educator, you may use activity #43 "Have Seeds Will Travel" as an additional resource.

SEED PHOTOS


Figure 1.


Figure 3.


Figure 2.


Figure 4.


Figure 5.

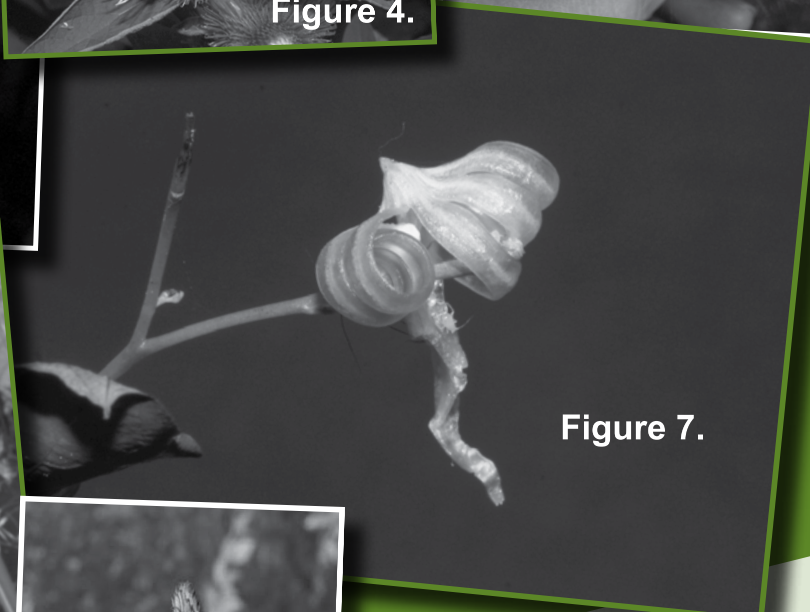


Figure 7.


Figure 6.


Figure 8.

All photos are by
Bioimages www.bioimages.vanderbilt.edu
http://www.cas.vanderbilt.edu/bioimages/pages/fruit-seed-dispersal.htm

Web Resources

Environmental Education for Kids—Seedy Characters
http://www.dnr.state.wi.us/org/caer/ce/eek/cool/seedy.htm

University of Georgia Savannah River Ecology Lab's Helicopter Seed Activity
http://www.uga.edu/srel/kidsdoscience/kidsdoscience-copters.htm

There's Snow Place Like Home:

Tracking the Range of Wolverines Over Time

Meet the Scientists!

Dr. Aubry,
research wildlife biologist:

One of my most interesting and exciting science experiences happened on the island of Tasmania (which is part of Australia). This was my first opportunity to experience the diversity of marsupials (pouched mammals) and egg-laying mammals that occur in the Australian region. I saw and photographed a Tasmanian devil, ringtail and brushtail possums, Bennett's wallaby (a small kangaroo), and a wombat. I learned all about the extinct Tasmanian tiger. One of my most memorable experiences was watching an **echidna** (one of only two egg-laying mammals in the world) hunt for bugs. They look for bugs in decaying leaves and under rotting logs. The echidna looks like a slightly deflated soccer ball that is covered with poisonous spines!

Dr. McKelvey,
wildlife ecologist:

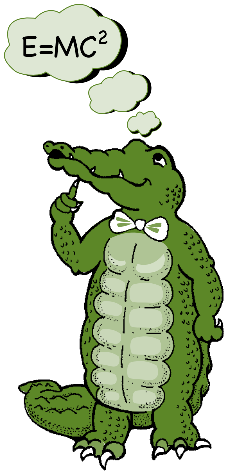
My favorite experience was digging out a wolverine snow-den in Glacier National Park. To study wolverines, scientists capture wolverine kits (baby wolverines). After the kits are captured, the scientists put tracking instruments on them. These instruments help us follow their movements.

To put the instruments on them, we first dig down through the snow to the wolverine den site. The den site is usually under about 8 feet of snow and under large rocks or downed trees. To find the dens, we have to look for wolverine tracks. I was lucky enough to follow tracks that led to the den. The den was visible by a small hole in the snow.

I was digging down, with the surface of the snow about 2 feet above my head when I broke through into the center of the den. Immediately, I heard the wolverine mom growling right beneath my feet. I had this image of an angry female wolverine crawling up my leg and gnawing on my head. But Jeff Copeland, who has years of experience with wolverines (but who was also standing safely on top of the snow) said: "It will be fine." It ended up being fine.

We were able to capture the two kits, and conditions were perfect for putting the instruments on them without causing them a lot of stress. We had to work quickly with mom circling about 50 meters away, waiting for us to be done! (In the picture, the wolverine kit is covered with a blanket to protect its eyes while we are studying it. The wolverine kit was released back to its mother when we were finished.)

Thinking About Science

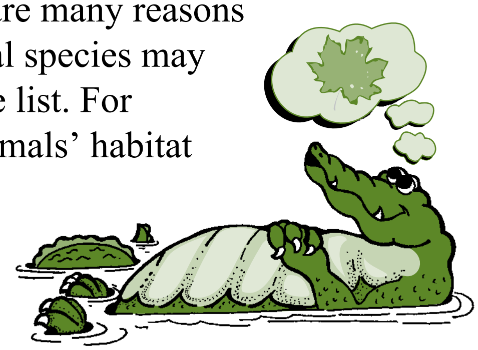


It is important for scientists to gather correct information about the topic they are studying. Not all information is reliable. Scientists need to be able to figure out whether the information they are collecting is reliable. In this study, scientists gathered information from several different places. They got information from museums, literature, and written material at state and federal buildings. The scientists did not use any information that was not reliable. When scientists (or you) use the Internet, care must be taken to know where the information came from. Usually, it is best to use Internet sites from the government (.gov), universities (.edu), or trusted sites like *National Geographic*.

If the scientists did not feel confident about their information source, they did not use that information. Therefore, some information that may have been useful was lost. It is important for scientists to keep **accurate** and reliable information. If the information is accurate and reliable, then other scientists may use that information too. Your teacher probably asks you to carefully write down your **observations** and data during experiments at school. Now you can see why that is important!

Thinking About the Environment

The Endangered **Species** Act is a law that was created in 1973. The law protects species that are in danger of becoming **extinct**. There are many reasons a plant or animal species may be placed on the list. For example, an animals' habitat may be getting smaller. If an animal loses its **habitat**, it may not be able to live in another area. In this study, the scientists examined wolverine habitat. The scientists decided to study the wolverine's range. The range is where the wolverines live across an area. The scientists wanted to know the range of the wolverines in the past and in the present.



Number Crunches

How many years ago did the Endangered Species Act go into effect?

Introduction

Wolverines are the largest member of the weasel family that lives on land. They are mammals that are not easily found **(figure 1)**. They live in areas far from humans and human development. Therefore, not much is known about these mammals.

Do you know what the largest weasel in the water is? Check out our web site to find out! www.scienceinvestigator.org!

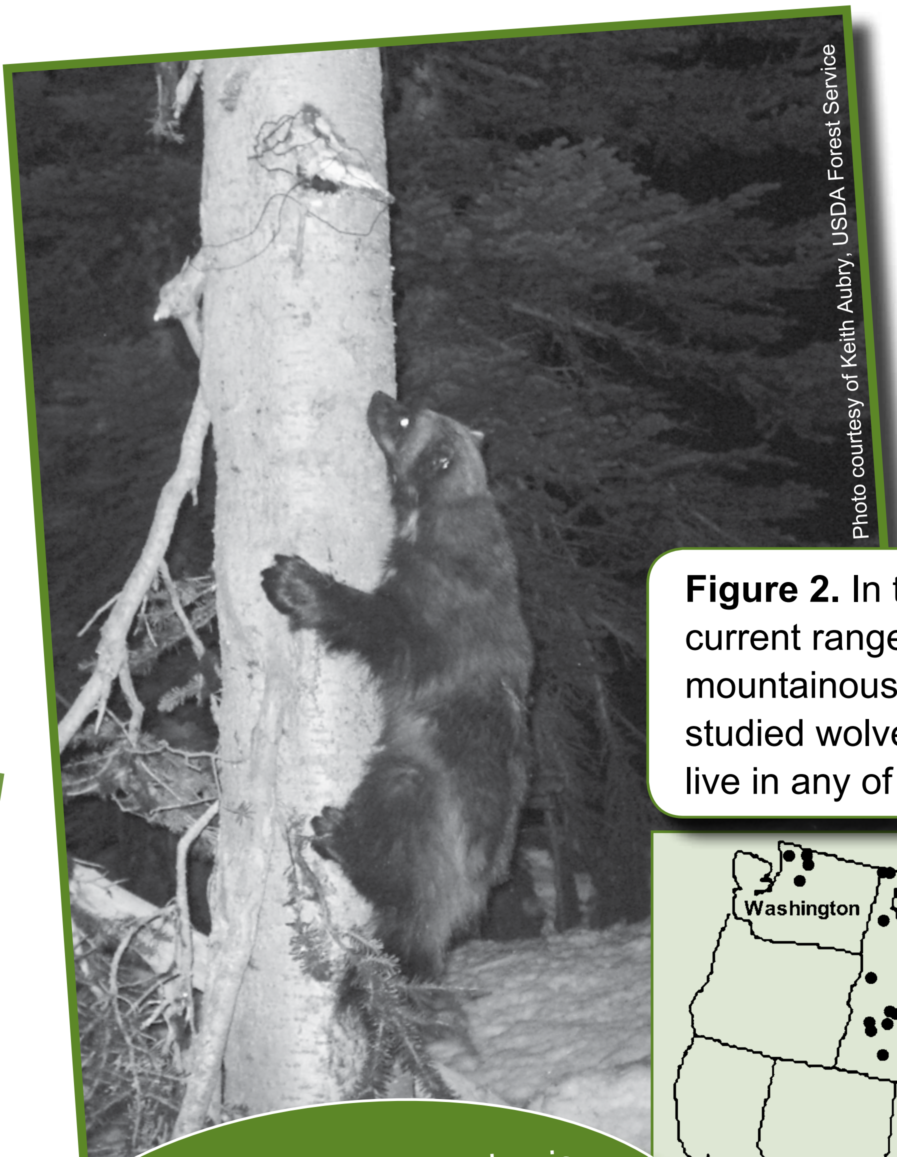
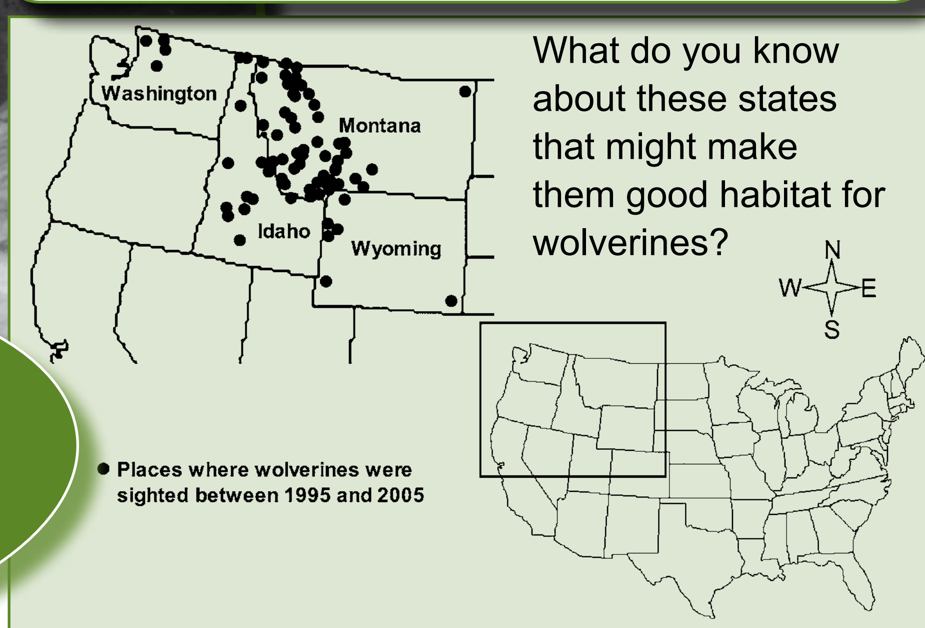


Photo courtesy of Keith Aubry, USDA Forest Service

Figure 1. The wolverine is well-adapted for living in snowy environments. Look at the picture and name one adaptation the wolverine has to allow it to live in the snow.

Wolverines are mostly scavengers. This means that they feed on dead animals. Sometimes wolverines travel great distances in a day in search of food or shelter. Wolverines may seek shelter under fallen logs or boulders. Female wolverines give birth to their kits in snow caves. Wolverines are currently found in most of Alaska and Canada and only in the northern portion of the Lower 48 States **(figure 2)**.

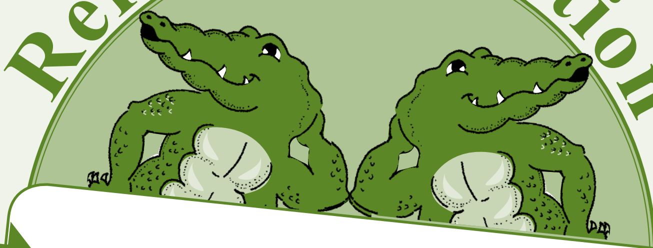
Figure 2. In the Lower 48 States, the wolverine's current range (1995–2005) is found in the mountainous Northern States. The scientists studied wolverine habitat in these states. Do you live in any of the states or areas that were studied?



What are the Lower 48 States? The Lower 48 States refers to all of the U.S. states that share a border with another state. Hawaii and Alaska are the only two states that do not share a border with the rest of the United States.

Before the scientists began their study, the range of wolverines was not well known. This was a problem. When some people asked for the wolverine to be listed as an Endangered Species their request was denied. One of the reasons the request was denied was because no one was certain where wolverines lived in the Lower 48 States. The scientists in this study, therefore, wanted to accurately map the wolverine's range over time. The scientists also wanted to study whether climate change is affecting the wolverines' range.

Reflection Section



- State in your own words and in the form of a question the problems the scientists were trying to study.
- What are some other animals that burrow or make dens for their homes?

Methods

By using a variety of sources, the scientists gathered records of wolverine sightings from 1801 through 2005. Each record included information identifying where the wolverines lived. The scientists divided the records into three periods.

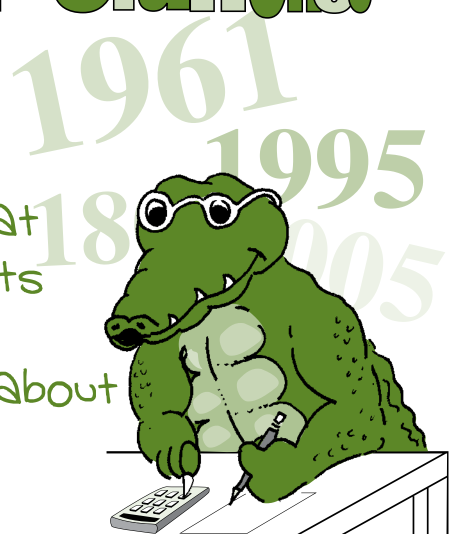
The periods were:

- **1995–2005 (current)**
- **1961–1994 (recent)**
- **1801–1961 (historical)**

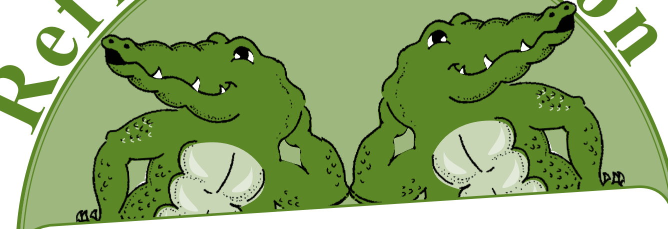
The scientists used computer software to create maps with the data. The scientists collected information about climate over time. The scientists also gathered information about spring snow cover from recent years. This information was added to the maps. When this information was added to the maps, the scientists could see how climate and snow affected the wolverines' range.

Number Crunches

What is the total number of years that the scientists obtained information about wolverines?



Reflection Section



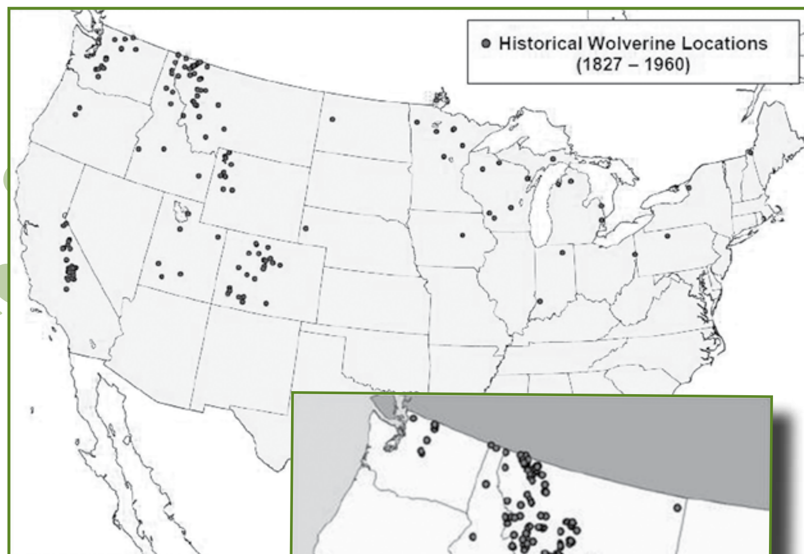
Why do you think the scientists divided the years up into different periods?

How do you think warmer temperatures might affect wolverines? (Hint: Look back at the "Introduction" section to see where wolverines typically give birth.)

Findings

The completed maps show that the range of wolverines has shrunk, based on changes in the wolverine records from historical to current times **(figure 3)**. It was also evident that wolverines depend on particular

A.



B.

C.

Figure 3. The historical distribution **(A)**, recent distribution **(B)**, and current distribution **(C)** of wolverines in the Lower 48 States.

habitat conditions for survival **(figure 4)**. Wolverines were found in alpine meadows and conifer forests. Alpine meadows are found high in the mountains. They are above the tree line **(figure 5)**. Conifer forests are areas with trees that have cones and typically do not lose their leaves in the fall or winter **(figure 6)**.

This study was the first time anyone accurately figured out the range of wolverines over time. This told the scientists several things. The scientists found that wolverines live in areas of the Lower 48 States where snowpacks stay through the spring. This is the time when wolverines make their dens. The scientists also found that most wolverines were found in alpine meadows and conifer forests.

Figure 4. Wolverine distribution and the location of alpine areas and conifer forests. What do you notice about where the wolverines live?

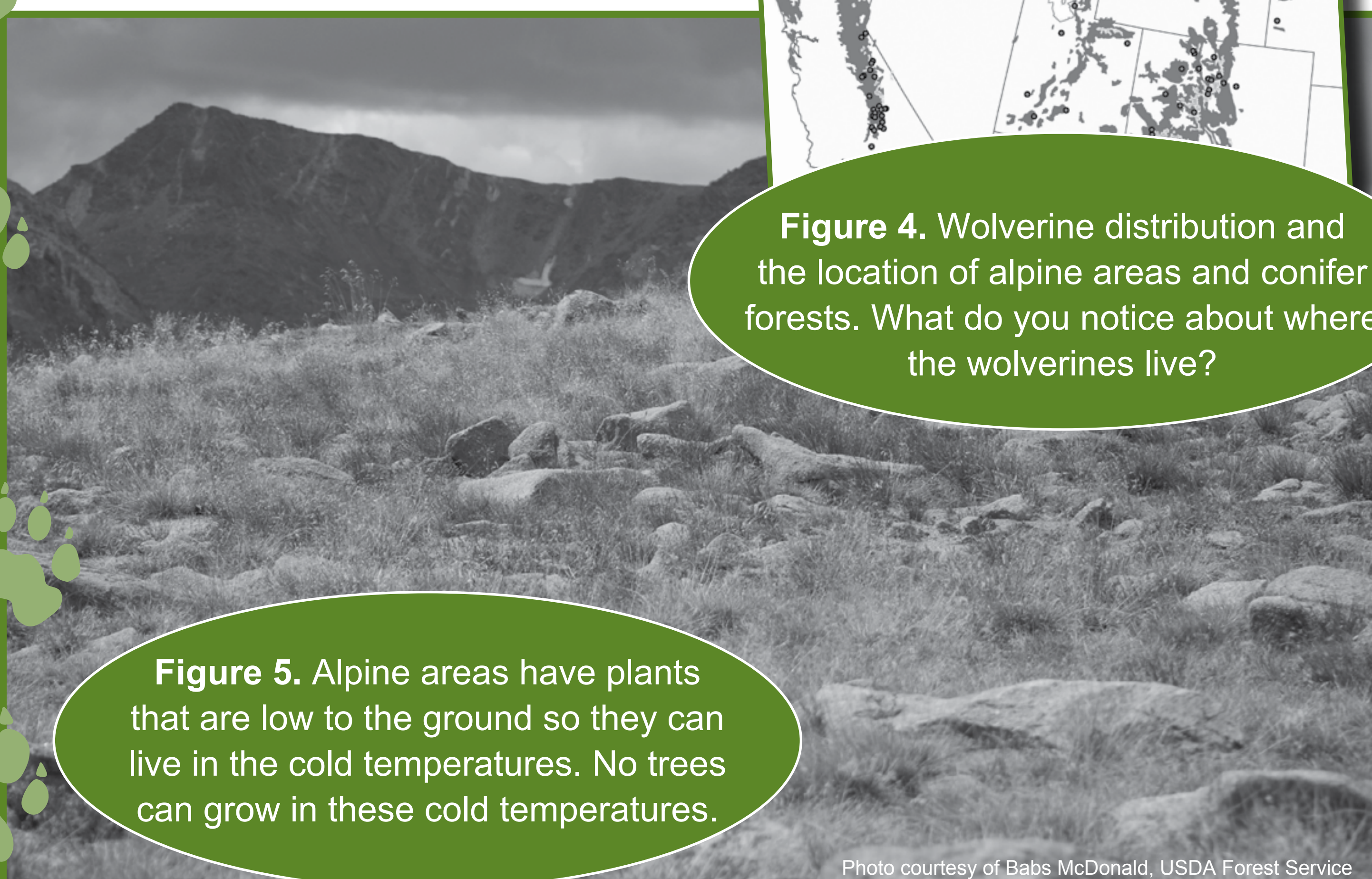


Figure 5. Alpine areas have plants that are low to the ground so they can live in the cold temperatures. No trees can grow in these cold temperatures.

Photo courtesy of Babs McDonald, USDA Forest Service

Figure 6. Many conifer trees grow in cooler climates.

Reflection Section

- Summarize what the scientists found in your own words.
- Do you think the findings support the idea that the wolverine's habitat may be in danger? Why or why not?

Discussion

Wolverines have already lost areas where they can live. The finding that wolverines live near areas that have spring snow cover is important. It is important because if the climate changes and becomes warmer, areas that currently have spring snow cover may have snow melt earlier in the year. If the climate changes in these areas, the wolverine habitat will change too. Additionally, the wolverine's reproduction may be affected. The scientists believe that more research needs to be done to fully understand what climate change means for wolverine populations.

Why would the wolverine's reproduction be affected? (Hint: Think about why wolverines need spring snow cover.)

Based on what you have learned from this article, do you think it is possible that the wolverine may need to be listed as an endangered species at some point? Why or why not?

Pronunciation Guide

ā	as in ape	ū	as in use
a	as in car	u	as in fur
ē	as in me	ü	as in tool
i	as in ice	ŋ	as in sing
ō	as in go	ə	as in about (both a and u)
oi	as in for		

Accented syllables are in **bold**.

Glossary

Accurate (**ak** ür ət): Free from error.

Echidna (ə **kid** nə): A type of egg-laying mammal that is also known as a spiny anteater.

Extinct (ek **stin(k)t**): No longer living.

Marsupial (mar **sūp** ē ul): A pouched mammal.

Habitat (**hab** uh tat): Environment where a plant or animal naturally grows and lives.

Observation (**ob** sür **vā** shun): Watching carefully and making note of details to help arrive at a judgment.

Reliable (re **lī** ə bəl): Dependable.

Species (**spē** sēz): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure.

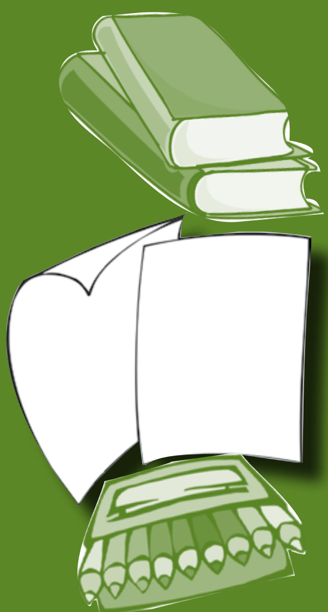
Accented syllables are in **bold**.

This article was adapted from Aubry, K.B.; McKelvey, K.S.; Copeland, J.P. 2007. Distribution and broadscale habitat relations of the wolverine in the contiguous United States. Journal of Wildlife Management. 71(7): 2147–2158. http://www.treesearch.fs.fed.us/pubs/28925

FACTivity

Time needed: Two class periods

Materials needed per student group:



- Animal field guides that include range maps, such as bird, reptile, amphibian, or mammal guides
- Two blank maps of the United States (see page 61)
- Two pieces of blank white 8 ½ x 11 paper
- Markers

The question students will answer in this FACTivity is:

What is the geographic range of an animal?

The process students will use to answer this question is:

In the first class period:

1. Choose an animal to study that lives in the United States. This animal may be selected from one of the field guides.

2. Using the field guide and other sources, find out the following information about your animal:

- What is your animal's habitat? When you find out about the areas it lives in, mark those areas on one of the blank maps.
- What does your animal eat?
- Does your animal have predators? If so, what are they?
- What size is your animal?
- What does your animal look like?
- What is the climate where the animal lives?
- What are three adaptations your animal has so that it can live successfully in its habitat?

3. Use this information and any other interesting facts to create an Animal Fact File. The Animal Fact File should be displayed on two 8 ½ by 11 pieces of paper.

In the second class period:

1. One of the blank U.S. maps should be filled out with the current range where your animal is found. Label this map "Where [animal species name] Currently Lives." The other map will be used to make a prediction about how you think your animal's ▶

FACTivity continued

range will move as the climate becomes warmer. Think about what you read in the wolverine article to help you make this map. Label this map "Predicted Future Range of [animal species name]."

2. Once all of the groups have created an Animal Fact File and completed the two maps, the files and maps can be compiled into a class book.

Extension: For students that need an extra challenge, they can include an Animal Fact File and map on one of the predators or prey for their animal.

If you are a trained Project WILD educator, you may use the activity "Shrinking Habitat" on page 310.

National Science Education Standards addressed in this article:

Science as Inquiry: Abilities to do scientific inquiry, Understandings about scientific inquiry

Life Science: Reproduction and heredity, Regulation and behavior, Populations and ecosystems, Diversity and adaptation of organisms

Earth Science: Structure of the Earth system

Science in Personal and Social Perspectives: Natural hazards, Risks and benefits, Science and technology in society

Science and Technology: Understandings about science and technology

History and Nature of Science: Science as a human endeavor, Nature of science

Additional Web Resources:

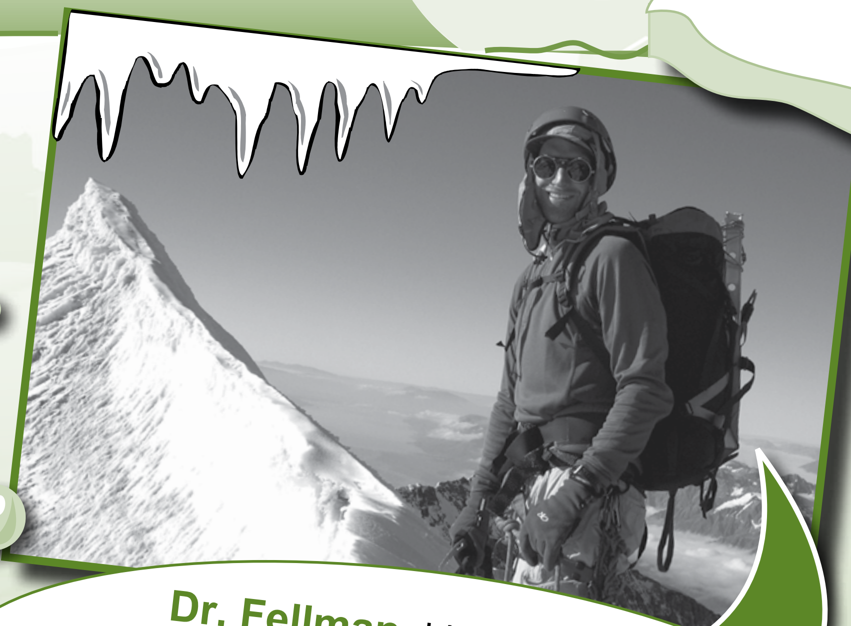
National Geographic wolverine information and pictures
http://animals.nationalgeographic.com/animals/mammals/wolverine.html

University of Michigan's Animal Diversity Web—Wolverine information
http://animaldiversity.ummz.umich.edu/site/accounts/information/Gulo_gulo.html

Frozen Food:

How Glaciers Provide Food for Animals That Live in the Ocean

Meet the Scientists!

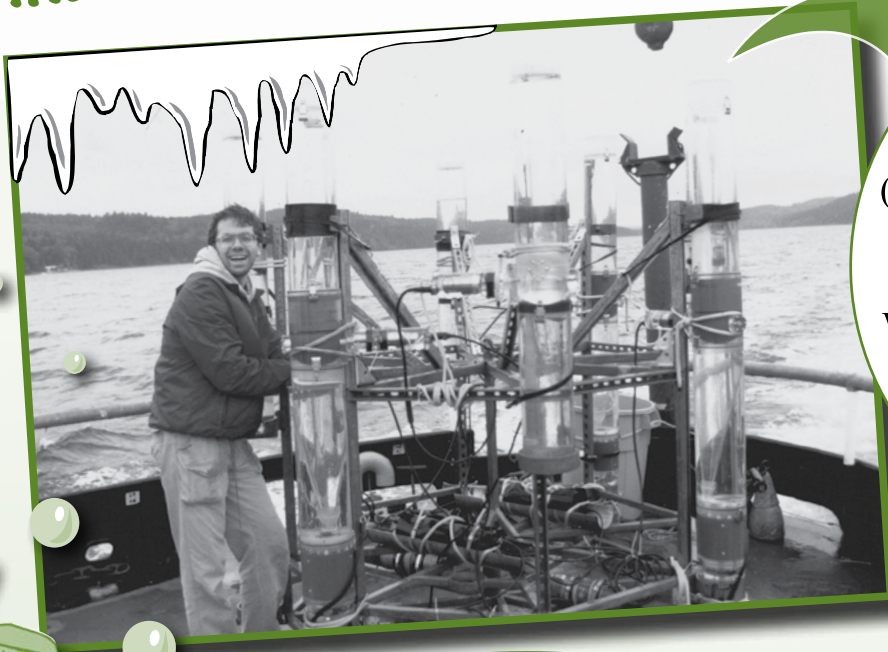


Dr. Fellman, biogeochemist:
My favorite science experience is going out to one of my field sites and finding several chewed salmon carcasses and bear footprints as big as my head!

Dr. Hood, biogeochemist (**bī** ō **jē** ō **kə** mist):
My favorite science experience is being able to climb around on the glaciers in the Juneau (Alaska) Icefield as part of my research.

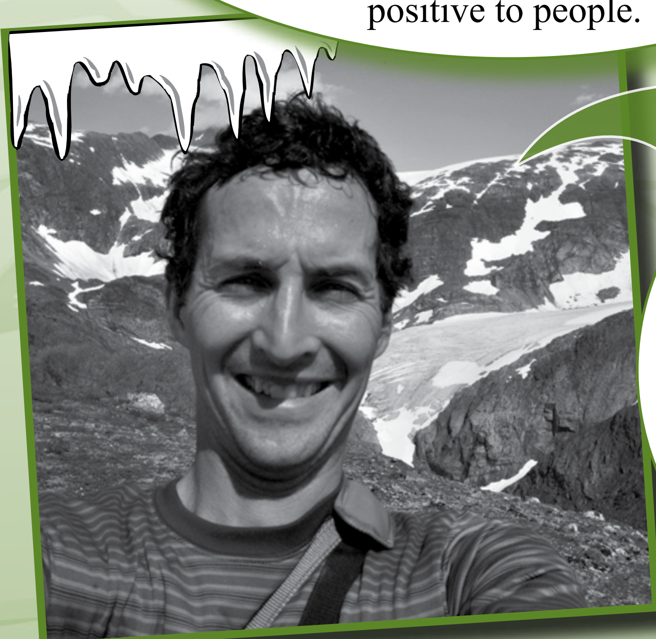
Dr. Spencer, biogeochemist:
My favorite science experience was witnessing the spring thaw on the Yukon River in Alaska. This is called an "ice-out." When the ice melts, it is like a river of ice. You can see it in the photo.

Meet the Scientists! continued



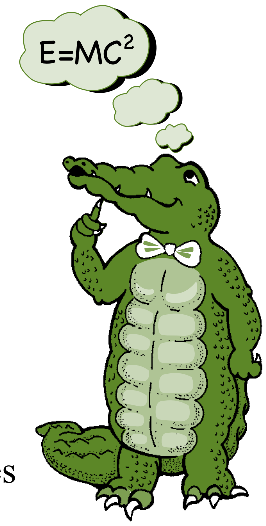
Dr. Hernes,
aqueous organic geochemist
(**aw** kwē us ôr **gə** nik **jē** ō **kə** mist):
My favorite science experience is seeing our research published. When a research paper is published, I know that it will influence how other scientists think for years to come.

Dr. Edwards,
ecologist (ē **käl** ō jist):
I've had so many wonderful experiences as a scientist I can't pick a favorite. From seeing koalas (kō **ow** las) in trees in Australia, to watching a grizzly bear catch salmon in Alaska, my research has allowed me to see things I never thought I'd see. Aside from the beautiful places, I am happy to know that I have discovered things that no one knew before. This has given me the feeling that I have contributed something positive to people.



Dr. Scott,
biological systems engineer:
One of my favorite science experiences was standing in the middle of a Rocky Mountain stream at 2 a.m. watching the Perseid (**pər** sē əd) meteor shower. The Perseid meteor shower occurs every August.

Thinking About Science



Have you ever wondered how scientists can tell the age of something very old? Often they use the element **carbon** to help them. Carbon is present in all living and once-living things. There are three types of carbon in living things. They are called carbon 12, carbon 13, and carbon 14. Living things contain very little carbon 14. They contain a lot of carbon 12. The amount of carbon 14 compared to the amount of carbon 12 is the same in all living things.

When living things die, the carbon 14 in them begins to decay. The carbon 12 does not decay. Scientists know exactly how fast carbon 14 decays. They can measure how much carbon 14 is present in something and compare that with how much carbon 12 is present. From this, they can estimate the object's age up to about 50,000 years old.

What Kind of Scientist?

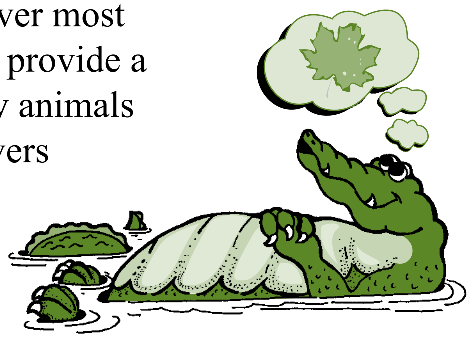
What is a biogeochemist? This kind of scientist studies the movement of chemical elements, such as carbon and nitrogen. These scientists also study how chemical elements relate to and become a part of living things over time.

What is an aqueous organic geochemist? This kind of scientist studies the impacts that organisms living in water (or ice) have on Earth.

What is a biological systems engineer? This kind of scientist seeks to design and implement systems. These systems are meant to act like or use life processes for conservation and restoration of the natural environment.

What is an ecologist? This kind of scientist studies the relationships of living things with each other and with the nonliving environment.

Thinking About the Environment



Oceans cover most of Earth. They provide a home for many animals and plants. Rivers and bays close to the coast also provide a home for animals and plants. Rivers carry **nutrients** that were washed into the rivers and bays from the surrounding land. These nutrients become available to the animals living in the water. This also happens in areas where there are glaciers. As glaciers melt, whatever was frozen in or beneath them runs into coastal rivers and bays **(figure 1)**.

Introduction

From studies of rivers with forests along their banks, scientists know that some plant material gets washed into rivers and bays. Plant material, like all living things, contains carbon. The carbon is used by some animals living in the rivers and bays. These studies

Figure 1. As this glacier melts, its **freshwater** goes into the bay.

have found that as the carbon in the plant material ages, it is less useful to animals living in the water.

In this study, the scientists studied glaciers and their nearby rivers in Alaska **(figures 2 and 3)**. The water coming from glaciers can be quite old. This water might contain nutrients such as carbon. This carbon could be at least 5,000 years old. The scientists wondered about the glacier water running into coastal rivers and bays. They wondered if the carbon in the water was too old to be useful to animals living in the rivers and bays.

Figure 2. The areas studied by the scientists.

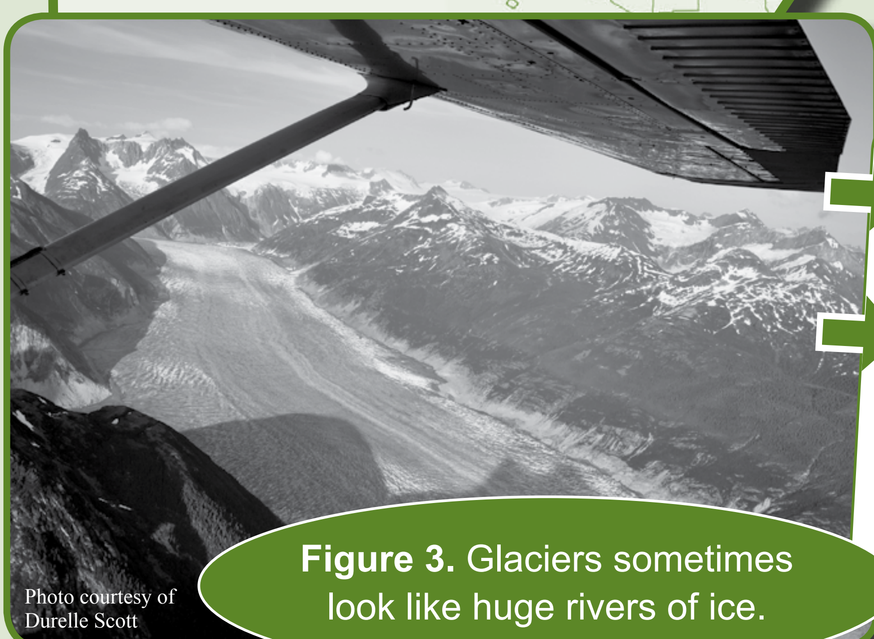
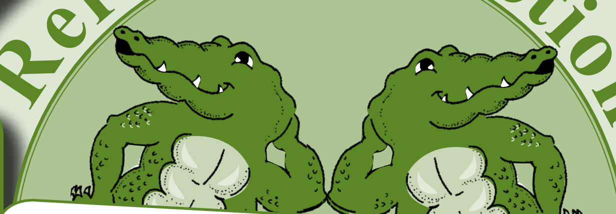


Figure 3. Glaciers sometimes look like huge rivers of ice.

Reflection Section



- State what the scientists wanted to study in the form of a question.
- Why did the scientists think the carbon might be too old to be useful to animals living in the rivers and bays? (Hint: Reread the last sentence in the first paragraph of the "Introduction.")

Method

The scientists collected water from 11 areas over 3 days in July 2008 **(figure 4)**. All of the water came from rivers containing melting glacier water. These rivers were not affected by ocean tides. This helped the scientists to be sure that the water was not affected by salt water in the ocean.

The scientists measured the amount of carbon in each container of collected water. They identified whether or not the carbon came from once-living plants or animals that are very old. They used carbon 14 dating to determine the age of the carbon. The pieces of material in the water were so small they could not be seen by the naked eye.

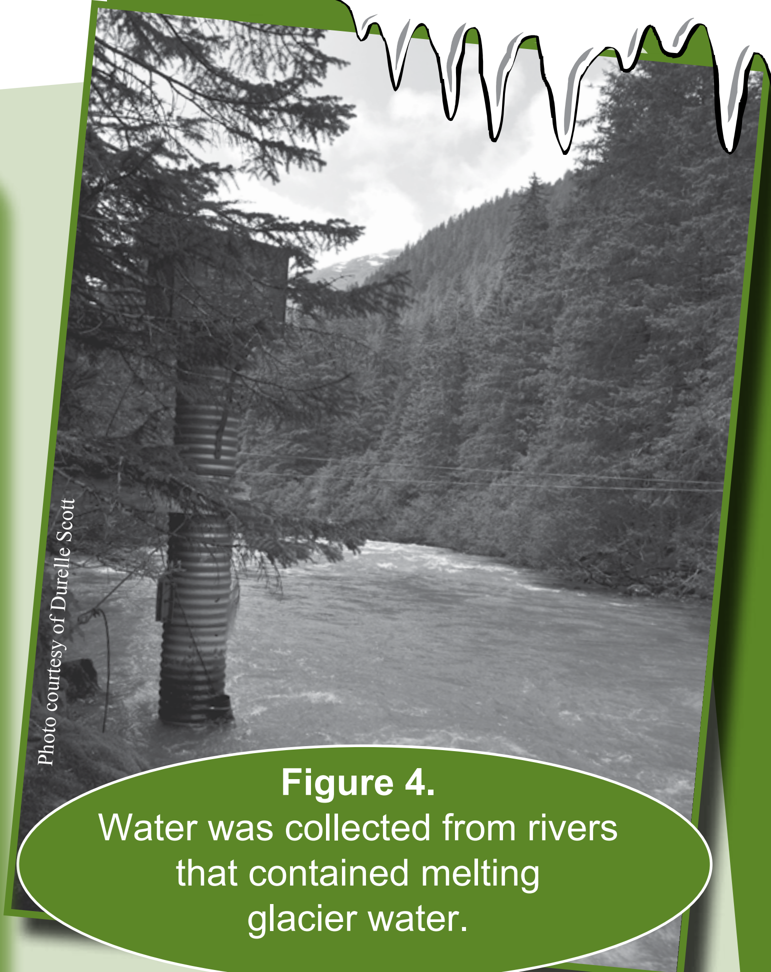


Photo courtesy of Durelle Scott

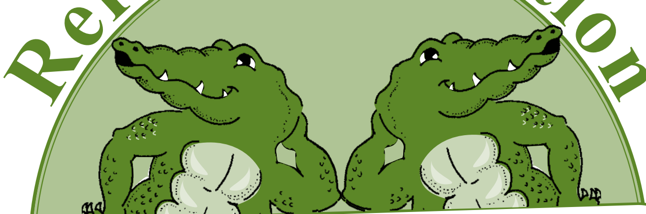
Figure 4.
Water was collected from rivers that contained melting glacier water.

Findings

The scientists knew that the glaciers covered ancient forests. The scientists found, however, that glacier water contained little material from ancient forests. They found that most of the glaciers' carbon came from microbes. Microbes are too small to be seen by the naked eye. They include **bacteria**, **fungi**, and **algae**.

Some kinds of bacteria can live in glaciers. The scientists believe that bacteria living in the glaciers have been eating old plant material for thousands of years. The old plant material came from the ancient forests. The carbon that is coming from glaciers today is made up of the remains of bacteria.

Reflection Section



- Why did the scientists avoid getting salt water in their samples?
- Think about the water coming out of the glaciers. Do you think the scientists found that the carbon was quite old? Why or why not?

The scientists discovered that the larger the glacier was, the older the carbon was in the glacier water. The scientists also found something different than what scientists before them found. These scientists found that the older the carbon in the glacier water was, the more useful it was to animals living in the rivers and bays. In earlier studies, scientists found the opposite to be true.

- Are you surprised that the glacier water contained little material from ancient forests? Why or why not?
- What might happen to the flow of glacier water as the global climate changes?

Discussion

Glacier water is different than water flowing down rivers with forests along their banks. It is different in at least two ways. First, the carbon in the glacier water comes from microbes, not from grasses and trees. Second, the older the carbon in the glacier water is, the more useful it is to animals living in the rivers and bays.

As the climate changes, the temperature will rise in the northern regions of Earth **(figure 5)**. This will cause glaciers to melt faster. More carbon will be flowing into rivers and bays near the glaciers. Scientists do not know how this will change the **ecosystem** of the rivers and bays. They believe, however, that a greater amount of carbon will provide more nutrients to animals living in the rivers and bays.

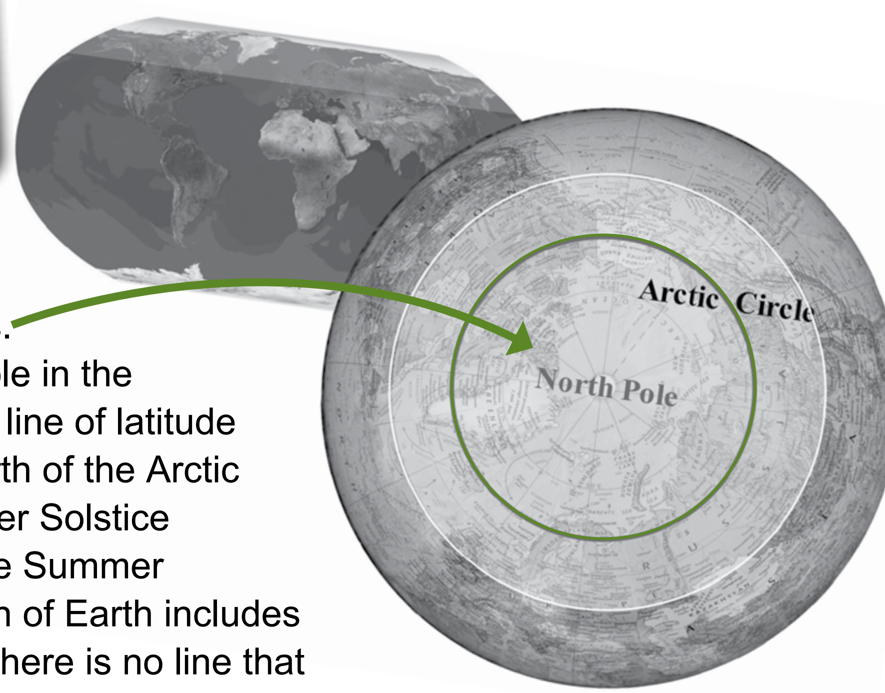
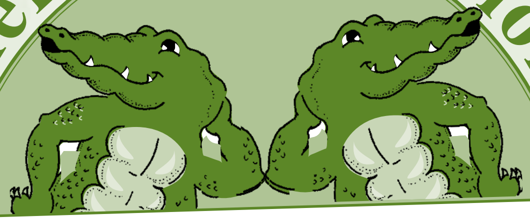


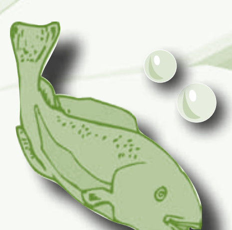
Figure 5. The northern region of Earth is shown lightly shaded in both images. On the right, you can see the North Pole in the center. The Arctic Circle is an invisible line of latitude on Earth's surface. Within the area north of the Arctic Circle, the sun never rises on the Winter Solstice (December 21) and it never sets on the Summer Solstice (June 21). The northern region of Earth includes an area south of the Arctic Circle, but there is no line that defines the exact area. Glaciers are found in Earth's northern region, including areas south of the Arctic Circle.

In the short term, more carbon and nitrogen might be helpful to animals living in the rivers and bays. In the long term, the scientists wonder what will happen after the glaciers have melted. There may no longer be very old carbon flowing into the rivers and bays.

Reflection Section



- Are you surprised that carbon that is thousands of years old is useful to animals living in nearby rivers and bays? Why or why not?
- As more glacier water runs into rivers and bays, will more or less nutrients be available to animals living there?
- In the long term, what might happen to the food source coming from glaciers?



Glossary

Algae (**al** jē): Simple, plantlike organism.

Bacteria (bak **tēr** ē uh): A large group of one-celled organisms, too small to be seen by the naked eye.

Carbon (**kar** bun): A chemical element present in all life forms.

Ecosystem (ē kō **sis** tem): Community of plant and animal species interacting with one another and with the nonliving environment.

Freshwater (fresh **wa** tur): Having to do with or living in water that is not salty.

Fungi (**fun** jī): Organisms without chlorophyll that reproduce by spores. Mushrooms, molds, mildews, and toadstools are examples.

Nutrients (nu trijənt**):** Any substance found in foods that are necessary for plants and animals.

Accented syllables are in **bold**.

This article was adapted from Hood, E.; Fellman, J.; Spencer, R.G.M.; Hernes, P.J.; Edwards, R.; D'Amore, D.; Scott, D. 2009. Glaciers as a source of ancient and labile organic matter to the marine environment. Nature. 462: 1044–1047.

Pronunciation Guide

ā	as in ape	ū	as in use
a	as in car	u	as in fur
ē	as in me	ü	as in tool
i	as in ice	ŋ	as in sing
ō	as in go	ə	as in about (both a and u)
oi	as in for		

Accented syllables are in **bold**.

FACTivity

Time required: 30 to 40 minutes

Materials needed:

• One page of lined paper and pencil for each student.

• A copy of page 49 for each student. (Optional: An unlined piece of paper, scissors, and glue for each student.)

The question students will answer in this FACTivity is:

What does photographic evidence appear to tell us about glaciers over the last century?

The process students will use to answer the question is as follows:

1. Students may work on page 49 in the journal, or may work from a sheet that was copied from this page. These are photographs of five glaciers in Alaska. The photographs on the left were taken in the early 1900s. The photographs on the right were taken in 2000.

2. Students will examine these photographs and do two main tasks.

- First, students will carefully observe the photographs and match the glacier photograph on the left with the glacier photograph on the right. Students may draw a line connecting the matching glacier photographs. If students are using a copy of the photographic sheet, they may cut the photos out and paste the pairs side-by-side on a separate sheet of paper.
- Each student will select two pairs of matching photographs to observe.

3. Students will study each pair of photographs for 10 seconds. From this, students should form an overall impression of the photographs and write down their impression on a sheet of paper. In the next 4 minutes, students should compare and contrast the early photographs with the more recent photographs. To assist with the observation, students may divide each photo into quadrants (four equal areas) and study each section to see what new details become visible.

4. Based on these observations, students should list three things they might conclude from the two pairs of photographs.

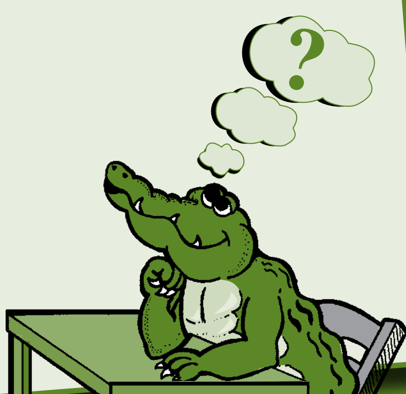
FACTivity continued

5. Hold a class discussion about the students' observations. What was the students' overall impression? What did students conclude about glaciers based on the photographs?

6. Hold a class discussion about photographic evidence. Some questions to discuss are:

- Can photographic evidence be trusted? Why or why not?
- How do photographs provide information that words cannot?
- What might add to the photographic evidence presented by these photographs?

Now, answer the question posed at the beginning of this FACTivity.



This FACTivity was adapted from http://www.windows2universe.org/teacher_resources/glacier_then_now.pdf. The photographs were provided by the Glacier Photograph Collection. Boulder, Colorado USA: National Snow and Ice Data Center/World Data Center for Glaciology, http://nsidc.org/

National Science Education Standards addressed in this article:

Science as Inquiry: Abilities to do scientific inquiry, Understandings about scientific inquiry

Life Science: Reproduction and heredity, Regulation and behavior, Populations and ecosystems, Diversity and adaptation of organisms

Earth Science: Structure of the Earth system

Science in Personal and Social Perspectives: Natural hazards, Risks and benefits, Science and technology in society

Science and Technology: Understandings about science and technology

History and Nature of Science: Science as a human endeavor, Nature of science

If you are a Project WET-trained educator, you may use the activity "Old Water," page 171, as a supplemental activity.

Web Site Resources

http://www.fs.fed.us/r10/tongass/forest_facts/resources/geology/icefields.htm: Tongass National Forest, icefields and glaciers

http://www.pbs.org/wgbh/nova/vinson/glacier.html: The life cycle of a glacier.
This slide show traces the journey of a snowflake onto a glacier and eventually reaching the sea.

http://ga.water.usgs.gov/edu/earthglacier.html: U.S. Geological Survey: glaciers and icecaps. Focuses on glaciers as a source of the world's freshwater.

The research reported in this article was funded in part by the Hydrologic Sciences Program of the U.S. National Science Foundation.

Holgate Glacier 1909. Photograph by Ulysses Sherman Grant

2000. Photo by Bruce F. Molina

McCarty Glacier 1909. Photograph by Ulysses Sherman Grant

2004. Photograph by Bruce F. Molina

Pedersen Glacier 1909. Photo by Ulysses Sherman Grant

2004. Photograph courtesy of the U.S. Geological Survey

Toboggan Glacier 1909. Photo by Sidney Page

2004. Photo by Bruce F. Molina

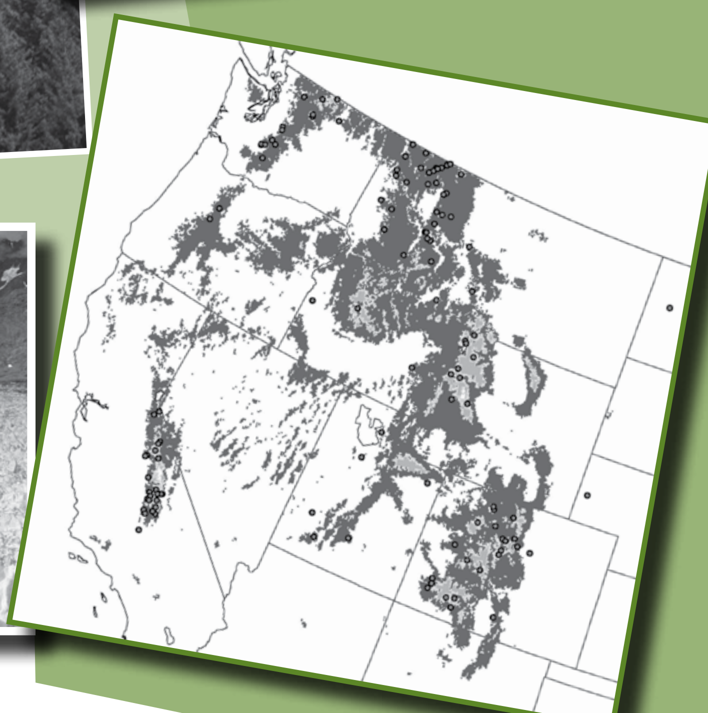
Muir Glacier 1941. Photograph by William O. Field

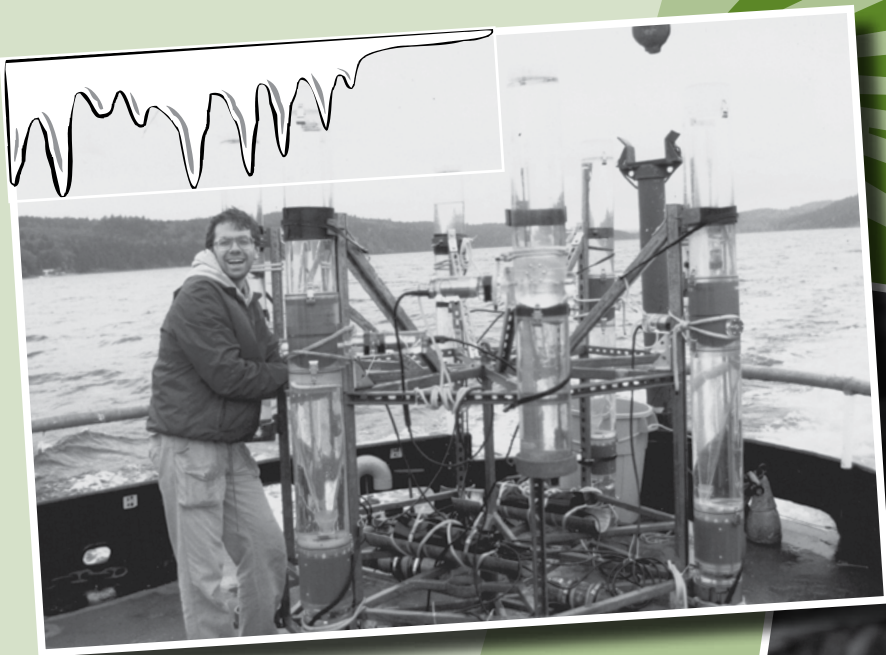
2004. Photo by Bruce F. Molina

Investi-gator Photo Challenge

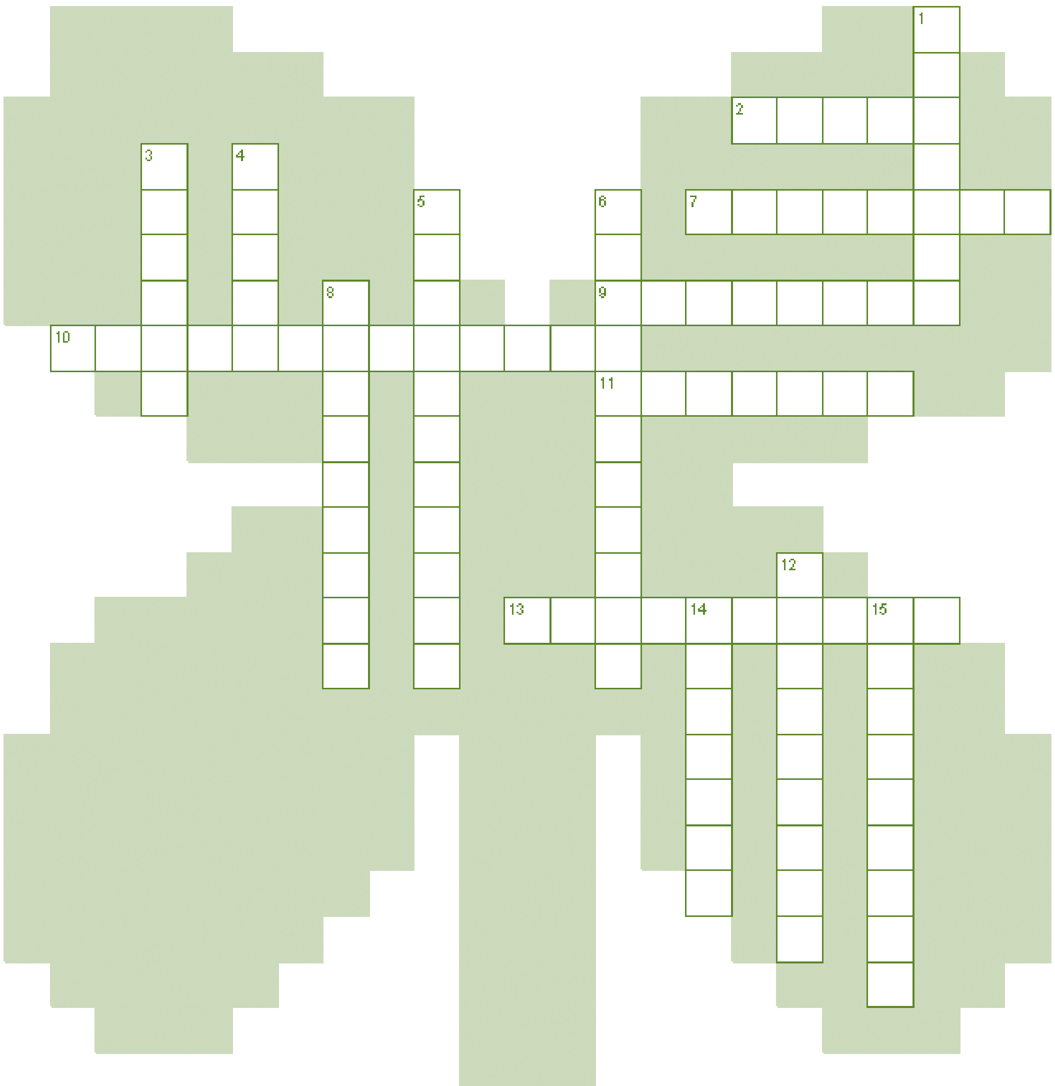
Pick one of the following pictures and see if you can remember which article contained the photo and why. Write two to three sentences explaining how you know which article contained the photo.

See how many you can get right!





Crossword Puzzle



Across

2. Organisms without chlorophyll that reproduce by spores
7. Free from error
9. Dependable
10. This kind of scientist studies the movement of chemical elements, such as carbon and nitrogen
11. No longer living
13. Having to do with or living in water that is not salty

Down

1. The average condition of weather over large areas, over a long time, or both
3. A chemical element present in all forms of life
4. Simple, plant-like organism
5. Watching carefully and making note of details to help arrive at a judgment
6. Animals that have a backbone
8. A scientist that studies the relationship of living things with each other and the nonliving environment
12. Pouched mammals
14. Environment where a plant or animal normally grows or lives
15. A community of plant and animal species interacting with one another and the nonliving environment

Word Search!

V
G B P
R F B
X U S X Y
M Y U U X
U T S J A M Y
M I M P Q N A
G J O S F Y M A B
X H V F L R N K I
V X B T L X E V X O H
T L P E V E R D H A B I T A T T S I G O L O C E P P Q F Q
V Y B P M O N N R N N O I T A V R E S B O Z M N Q K C
I D Y A L J E Y I H W P Y W T P O I F Q A Y T W K
G S Q K K M P O K F U Y H W K C G S K A D N N
R K D X N R E K N S Y S K T H W U L V T Y
H J K R S E T A R B E T R E V W S J K
J P E A G L A A P R C Q M K P N N
F G F W X I M C F Q O I K X B
F Y Z M Y U A I C Z W S P F K
J Q E L R R Q B L U E T Y C A
U Q F I X B N P   L C R N C S A B
R Q D G O F K   E W A E X T G
G H L X N C O   X V T D P E E
C A O B U L   T P E Y C M
D S H E C F   I J H T K Q
B V S K F   N O T A S
S R C P K   C S X U A
Z P I R   T R V D
K B N I   R Y N O
E C   C L

1. Free from error
2. Simple, plant-like organism
3. This kind of scientist studies the movement of chemical elements, such as carbon and nitrogen
4. A chemical element present in all forms of life
5. The average condition of weather over large areas, over a long time, or both
6. A scientist that studies the relationship of living things with each other and the nonliving environment
7. A community of plant and animal species interacting with one another and the nonliving environment
8. No longer living
9. Having to do with or living in water that is not salty
10. Organisms without chlorophyll that reproduce by spores
11. Environment where a plant or animal normally grows or lives
12. Pouched mammals
13. Watching carefully and making note of details to help arrive at a judgment
14. Dependable
15. Animals that have a backbone

Note to Educators

Science education is increasingly in the spotlight as society recognizes the importance of scientific literacy to the Nation's future. As teachers of science, you are being asked to prepare your students by providing both breadth and depth in science topics and process. The *Investi-gator* is a resource to help you teach both scientific content and process to your students. The *Investi-gator* integrates science with a number of disciplines, including language arts, geography, math, and social studies. Therefore, the *Investi-gator* can be used for team teaching or simply to reinforce the interdependent nature of learning and knowledge to your students.

You understand the importance of hands-on learning. Although hands-on experience is a critical component of student scientific learning, science education standards have increasingly also highlighted the role of minds-on learning. True scientific literacy occurs when students can critically think about scientific questions, processes, and findings, as well as participate in data collection, observation, and analysis. You can use the *Investi-gator* to introduce science as a process that integrates minds-on learning with hands-on learning. At the end of each article, an easy-to-do activity, called a FACTivity, is provided to highlight a topic or process concept from the article. A reference to appropriate Project Learning Tree (PLT), Project WET, and Project WILD activities is also provided for those educators certified in those programs. For more information about these programs, visit **http://www. plt. org, www.projectwet.org**, or **www.projectwild.org**.

How to Use This Journal in Your Classroom

The *Investi-gator* is written at the fifth-grade level. Each article is written from an actual published scientific paper presenting contemporary environmental research. At the back of this journal, you will find two resources to help you use the journal more effectively. A matrix is given that indicates which national science education standards can be addressed by each article. A lesson plan is also provided that can be used with all four of the articles. The lesson plan helps you apply a reading strategy that will increase student comprehension. Along with the FACTivity, the lesson plan will help you integrate minds-on and hands-on scientific learning.

Help Us Improve the *Investi-gator*

Visit http://www.naturalinquirer.org to find student and teacher evaluation forms. These forms give you an opportunity to provide feedback that will help us improve the journal. Please take a moment to complete the evaluation form and if possible, invite your students to evaluate the journal as well. By completing the evaluation form, your students can learn the importance of providing assessment, much as you do when you assess their achievement. You may also make comments via the Web site. For more information, to ask questions, or to provide comment, contact:

Dr. Barbara (Babs) McDonald
Forest Service
320 Green St.
Athens, GA 30602-2044
706.559.4224
bmcdonald@fs.fed.us

(Please put "Educator Feedback" in the subject line)

The *Investi-gator* is a member of the *Natural Inquirer* family. The *Natural Inquirer* is a science education journal for middle school students. To explore more resources for using these journals, visit the *Natural Inquirer* Web site at **http://www.naturalinquirer.org**

Visit the *Investi-gator* Web site at http://www.scienceinvestigator.org

Lesson Plan

Science Skills: Communication, Inquiry

National Science Education Standards:
Abilities to do scientific inquiry, Understandings about science inquiry, Science as a human endeavor

Note: This is a generic lesson plan that can be used with any *Investi-gator* or *Natural Inquirer* article.

Estimated Time

One and one-half class periods (plus an optional third period for the FACTivity)

Materials

- *Investi-gator* 2nd edition (one per student)
- 1 unlined piece of paper per student
- 1 lined piece of paper per student
- Pencils

Procedure

Day 1: 10-15 minutes

Introduce the scientific process, as expressed in scientific writing, to your students. Explain that scientists communicate with each other in writing by completing a scientific paper. A scientific paper is similar to what they do when they write a research paper. A scientific paper may have a number of sections, but they usually include:

1. **Introduction section.** The introduction gives the background of the research problem. It explains what the problem is and why it is a problem. It usually ends with a statement of the question the scientist wanted to answer or the specific problem to be solved.

2. **Methods section.** The methods section explains what kind of data or information the scientist collected, how it was collected, and how it was analyzed.

3. **Findings section.** The findings section presents the results of the data analysis and usually includes an interpretation of the analysis. An interpretation of the analysis is different than the analysis itself. The analysis is a process of data or information reduction, and may include mathematical and statistical processes. Mathematical and statistical analyses are not mandatory, as many forms of analysis may include non-numerical processes. The interpretation is the meaning given to the analysis. Different scientists could even interpret the same data or information in different ways.

4. **Discussion (or implications) section.** In this section, the scientist usually discusses the findings and interpretation in light of the original problem presented in the Introduction section. In addition, this section often suggests new questions or problems to be answered or solved.

Explain to your students that there are many ways to solve scientific problems or answer scientific questions. The type of data or information collected and the way it is analyzed depends on the problem or question. Introduce the *Investi-gator* by telling them that they will be reading a scientific paper written at their grade level. Tell them that this paper is based on an actual scientific paper written by scientists working for the U.S. Forest Service, a United States government agency.

1. Briefly introduce the article you have chosen, emphasizing the topic and the particular research question being addressed in the article. Give students two pieces of paper each. Have the students label the unlined sheet of paper with K-W-L and draw three columns—Column 1 **K** (What do you **K**now?), Column 2 **W** (**W**hat do you think you will learn?), Column 3 **L** (What did you **L**earn?). Label the lined sheet of paper “Reflection Questions.” Have student divide the sheet of paper in four sections. Label the sections “Introduction,” “Method,” “Findings,” and “Discussion.”

2. Place students into groups of 3 to 5. Have students fill in the “K” column with words, terms, or phrases from their background or prior knowledge regarding the topic of the article. If you are having them draw on a topic previously learned, then the K column may be topic-related. But if the topic is something brand new, and they don’t know anything (or much) about it, you should use the K column to have them bring to mind a similar, analogous, or broader idea.

3. Hand each student an *Investi-gator*. Have students predict what they might learn about the topic. (Complete the “W” column.) Students may look through the article to glance at headings, pictures, and charts. This technique helps focus their attention on key ideas. Students may add ideas about what they want to learn about the topic in the middle column too.

4. For homework, ask students to read the article that you have chosen. Students should read the entire article, but they do not need to read the FACTivity or the Reflection Questions.

Day 2: Entire class period

Within each group, have students read the article aloud. Have students alternate reading paragraphs. At the end of each section have students discuss and answer the reflection questions on the piece of paper labeled “Reflection Questions.”

After reading, students should fill in their new knowledge gained from reading the content. The student’s misconceptions about the topic from the Know column before reading the article may be addressed from the knowledge gained from actually reading the article. Hold a class discussion about misconceptions, predictions, and new knowledge. Use these questions to get you started:

1. What misconceptions did you have? Where did those misconceptions come from?
2. What clues did you use to predict what you might learn from the article? Were your predictions accurate? Why or why not?
3. What did you learn from the article that cleared up a misconception?

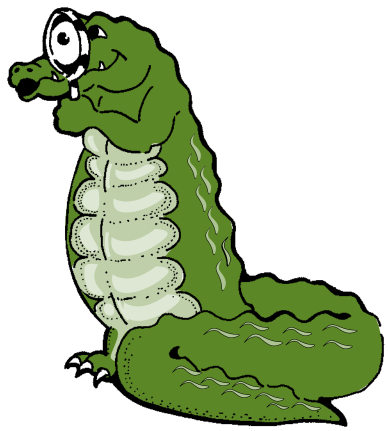
If you have time or as an extension,

1. Have each group designate a presenter. The presenter will present a reflection section answer and rationale to the class. Have the student read the reflection question before giving the answer and rationale. Continue with all groups until all Reflection Questions have been presented.

2. If time allows, hold a class discussion about the article. What did the students learn? What did they like or dislike about the article? Challenge the students to discuss how the research they just read might affect them personally. How might it affect their community?

Day 3: Continue with the FACTivity if needed.

Assessment
Collect the students' K-W-L sheets and reflection question sheets. You can assess students comprehension from the responses found on the sheet.



Assessment Rubric

For each column (K, W, L)	No attempt to answer	1 to 2 items identified	3 to 4 items identified	5 or more items identified
SCORE	0	1	2	3

Assessment scoring:

Total Score 0 = 0 points

Total Score 1–2 = 1 point

Total Score 3–4 = 2 points

Total Score 5–6 = 3 points

Total Score 7–8 = 4 points

Total Score 9 = 5 points

Reflection Section Answer Guide

Note to Educator: The purpose of the Reflection section questions is to encourage students to think critically about what they have read. The following "answers" are only suggestions to assist you in using these questions in the classroom.

Amphibious Assault: How Climate Change May Affect Amphibian Breeding

Introduction

What is the problem the scientists wanted to answer in this study? *Scientists wanted to find out how amphibian breeding may be affected by climate change.*

Why might cold-blooded animals be more quickly affected by climate change? *Cold-blooded animals may be affected more quickly by climate change because their body temperature and activities depend on the environment. Therefore, if the temperature of the environment changes, so do the temperature and activities of the cold-blooded animal.*

Method

Why do you think scientists chose to study frogs and toads in three different areas? *Scientists often choose to gather their data from more than one location because it helps the scientists make sure that their findings are reliable. Also scientists may want to compare similarities and differences across different areas and species.*

Why do you think scientists wanted to know what the daily air temperature was in the 3 months before breeding season? *To have a good understanding of the changing temperature and how that may affect amphibian breeding, the scientists needed to have several months of data on the air temperature. This way, the scientists could see how the temperature changed over that period and how that change may have affected the amphibians.*

Findings

Based on the scientists' findings, does it look like climate change is having an effect on when the amphibians breed? *Based on the scientists' findings, it does not look like climate change is having a significant effect on amphibian breeding, up to the time of the study (year 2000) and for most of the species and sites surveyed in this study.*

Look at the findings for the western toad. Why do you think it is important to test at different sites? *It is important to test at different sites because if the scientists had only tested two sites, they may not have seen a change at one site. Instead, they may have concluded that there were no changes at all.*

Look at the periods studied in figure 3. What is one possible reason the scientists found that frogs and toads were not breeding earlier? *The periods may not have been long enough to show enough of a change in the temperature. If the scientists had studied frog and toad breeding over the past 50 years, for example, they may have had different results.*

Discussion

Why would amphibians be particularly sensitive to changes in temperature? *Amphibians are cold-blooded, which means they are sensitive to changes in temperature.*

Do you agree with the scientists that more studies should be done? Why or why not? *This is an individual question. Students should be able to support their answers with sound logic and reasoning.*

Seed Ya Later! Predicting the Movement of Trees in a Changing Climate

Introduction

How does a tree move to a new location? *Tree species move to new locations through the movement of their seeds.*

Why do you think the scientists in this study wanted to include the movement of tree seeds into their models? (Hint: Reread the first two sentences in the "Introduction.") *The rate at which tree species can move in a changing climate is related to the method and distance of seed dispersal. If the scientists could include this information in their models, they can make more accurate predictions of what might happen in a changing climate.*

Method

Why is it important for the scientists to know how far and how fast seeds can move? *Trees move somewhat slowly as a species. The climate is changing, and therefore the scientists must be able to compare the rate of climate change with the rate of movement for different tree species.*

Why was it important to know which tree seeds step and which ones can jump? *Jumping seeds can travel longer distances and therefore may enable some tree species to move faster, over time, than other species. These species may be more successful at becoming established in new areas as the climate changes.*

Findings

As the climate warms, do you think different types of trees will be more likely to move north or south? Why? *Students should be able to reason that tree species will be more likely to move north, as a favorable climate will move farther north.*

The scientists found that it was easier to predict the movement of trees with wind-blown seeds. Do you think it was also easier to predict the movement of trees whose seeds can float downstream? Why or why not? *Students should realize that it is easier to predict the movement of plants and trees whose seeds can float, as the direction and speed of streams and rivers can be easily determined.*

Discussion

If a type of tree is able to successfully move to a new location, what else might move with it? *Animals that use the type of tree for habitat and as a food source would likely move as the trees move. This includes mammals, birds, and insects.*

Could the types of trees growing near your home change over the next 100 years? Why or why not? *Students should reason this for themselves, but should conclude that as the climate changes over the next 100 years, the types of trees growing near their home may change as well.*

There's Snow Place Like Home: Tracking the Range of Wolverines Over Time

Introduction

State in your own words and in the form of a question, the problems the scientists were trying to study. *What is the geographic range of wolverines over time? How could climate change affect the geographic range of wolverines?*

What are some other animals that burrow or make dens for their homes? *There are many different animals that burrow or make dens. Some examples include groundhogs, ants, hamsters, foxes, ferrets, chipmunks, badgers, moles, prairie dogs, pikas, rabbits, shrews, and sand dollars.*

Method

Why do you think the scientists divided the years up into different time periods? *The scientists divided the time because it was easier to discuss and compare their findings based on three smaller periods.*

How do you think warmer temperatures might affect wolverines? (Hint: Look back at the "Introduction" section to see where wolverines typically give birth.) *Warmer temperatures may cause the snow to melt earlier. If the snow melts earlier, the wolverine's denning habitat won't be as good.*

Findings

Summarize what the scientists found in your own words. *The scientists found that spring snow cover, alpine areas, and conifer forests were important to the geographic range of wolverines. They also found that by the 1950s, wolverine range had shrunk.*

Do you think the findings support the idea that the wolverine's habitat may be in danger? Why or why not? *This is an individual question. Students should be able to support their answers with examples from the article.*

Discussion

Why would the wolverine's reproduction be affected? (Hint: Think about why wolverines need spring snow cover.) *The wolverines make their dens in the snow. They reproduce and raise their kits in these dens.*

Based on what you have learned from this article, do you think it is possible that the wolverine may need to be listed as an endangered species at some point? Why or why not? *This is an individual question. Students should be able to support their answers with examples from the article.*

Frozen Food: How Glaciers Provide Food for Animals That Live in the Ocean

Introduction

State what the scientists wanted to study in the form of a question. *Is the carbon in glacier water too old to be useful to animals living in nearby rivers and bays?*

Why did the scientists think the carbon might be too old to be useful to animals living in the rivers and bays? (Hint: Reread the last sentence in the first paragraph of the "Introduction.") *Earlier studies of rivers with forests along their banks had shown that as carbon in plant material in the rivers gets older, it is less useful to the animals living in the rivers and bays. If the same thing were true of glaciers, the ancient carbon and nutrients would not be very useful to the animals.*

Method

Why did the scientists avoid getting salt water in their samples? *The scientists were studying freshwater coming from glacial rivers. If they got salt water in their samples, they would not be testing the glacier water.*

Think about the water coming out of the glaciers. Do you think the scientists found that the carbon was quite old? Why or why not? *Students should reason that because glaciers are quite old, the material being held in their ice is quite old as well. Regardless, students should be able to back up their answer with logic.*

Findings

Are you surprised that the glacier water contained little material from ancient forests? Why or why not? *This is an individual question and students should back up their answer with logic.*

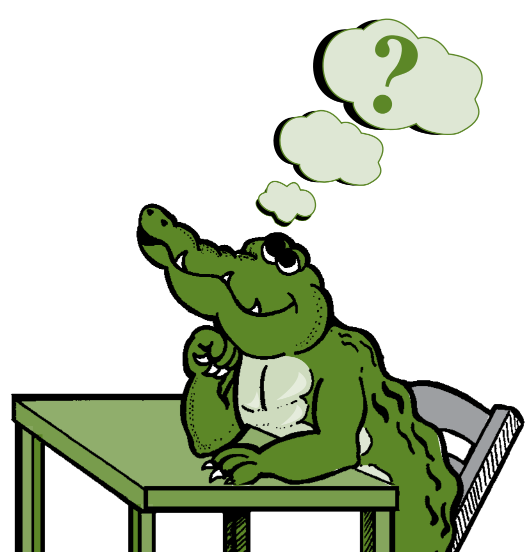
What might happen to the flow of glacier water as the global climate changes? *Students should realize that the glaciers will melt faster, causing more water to flow into rivers and bays.*

Discussion

Are you surprised that carbon that is thousands of years old is useful to animals living in nearby rivers and bays? Why or why not? *This is an individual question, however based on studies of rivers with forested banks, students should be surprised that the situation is different in glacial waters.*

As more glacier water runs into rivers and bays, will more or less nutrients be available to animals living there? *Students should realize that more nutrients will be available to animals living in rivers and bays near glaciers. This is true in the short term. However in the long term, especially after the glaciers have almost completely melted, fewer nutrients will be available.*

In the long term, what might happen to the food source coming from glaciers? *Students should reason that after the glaciers have melted, the carbon that is used as a food source will no longer be available to animals living in the rivers and bays.*



United States of America

National Science Education Standards for the Pacific Northwest Edition of the *Investi-gator*

Journal Article	Amphibious Assault	Seed Ya Later!	Snow Place Like Home	Frozen Food
Science as Inquiry				
Abilities Necessary to Do Scientific Inquiry	✓	✓	✓	✓
Understanding About Scientific Inquiry	✓	✓	✓	✓
Life Science				
Structure and Function in Living Systems	✓	✓	✓	✓
Regulation and Behavior	✓	✓	✓	
Populations and Ecosystems	✓		✓	✓
Diversity and Adaptations of Organisms	✓	✓	✓	✓
Earth Science				
Structure of Earth System	✓		✓	✓
Science in Personal and Social Perspectives				
Natural Hazards	✓		✓	
Risks and Benefits	✓	✓	✓	✓
Science and Technology in Society	✓	✓	✓	✓
Science and Technology				
Understanding About Science and Technology	✓	✓	✓	✓
History and Nature of Science				
Science as a Human Endeavor	✓	✓	✓	✓
Nature of Science	✓	✓	✓	✓

What Is the U.S. Forest Service?

The Forest Service is a part of the United States Department of Agriculture (USDA). It is made up of thousands of people who care for the Nation's forest land. The USDA 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, 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 USDA Forest Service are scientists, whose work is presented in the journal. USDA 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 Cradle of Forestry Interpretive Association?

The Cradle of Forestry Interpretive Association (CFIA) is a nonprofit organization founded in 1972 by a group of people interested in forest conservation. The CFIA helps the Forest Service tell the story of forest conservation in America, and it helps people better understand both forests and the benefits of forest management. The CFIA invites everyone to visit its Forest Discovery Center in the Pisgah National Forest near Brevard, NC.

Learn more about the CFIA by visiting http://www.cradleofforestry.org.

What Is the Pacific Northwest Research Station?

The Pacific Northwest Research Station provides scientific information to land managers, policymakers, and citizens. The station has 11 locations in Alaska, Oregon, and Washington and about 500 employees. Their mission is to generate and communicate scientific knowledge that helps people understand and make informed choices about people, natural resources, and the environment. The station publishes two newsletters about recent research: *Science Findings* and *Science Update*.

These can be found at www.fs.fed.us/pnw/.

the Investi-gator Review Board

Felida Elementary School, Vancouver, Washington, Mrs. Beaman's 5th Grade Class

For additional information, please visit these Web sites:

Forest Service
http://www.fs.fed.us

Investi-gator
http://www.scienceinvestigator.org

Natural Inquirer
http://naturalinquirer.org

Forest Service Conservation Education
http://www.fs.fed.us/kids/ (Click on Conservation Education)

Forest Service Pacific Northwest Research Station
http://www.fs.fed.us/pnw/

Forest Service Pacific Northwest Research Station—For Kids
http://www.fs.fed.us/pnw/kids/

Forest Service Climate Change Resource Center
http://www.fs.fed.us/ccrc/

Discover the Forest
http://discovertheforest.org

National Oceanic and Atmospheric Administration Climate Change for Kids
http://www.education.noaa.gov/

Forest Service Northern Research Station—Interactive Atlas of Climate Change: Bird & Tree Species
http://www.nrs.fs.fed.us/atlas/