

# Natural



# INQUIRER

Ecosystem Services Edition

Volume 12, Number 1, Spring 2010



# Natural Inquirer

Ecosystem Services Edition • Volume 12, Number 1, Spring 2010

## **Produced by:**

The Forest Service and the U.S. Geological Survey

## **Editors:**

Babs McDonald, *Forest Service*

Jessica Nickelsen, *Cradle of Forestry Interpretive Association*

Rachel Small, *Cradle of Forestry Interpretive Association*

Michelle Andrews, *University of Georgia*

## **Graphic Designer:**

Carly Morganwalp, *U.S. Geological Survey*

## **Forest Service scientists highlighted in the journal:**

Dr. Ariel Lugo, *International Institute of Tropical Forestry*

Dr. Alice Chung-MacCoubrey, *Rocky Mountain Research Station (formerly)*

Dr. Diane DeSteven, *Southern Research Station*

## **U.S. Geological Survey scientists highlighted in the journal:**

Dr. Robert Gleason, *Northern Prairie Wildlife Research Center*

Dr. Ned Euliss, *Northern Prairie Wildlife Research Center*

Mr. Brian Tangen, *Northern Prairie Wildlife Research Center*

Dr. Glenn Guntenspergen, *Natural Resources Research Institute*

## **Other scientists highlighted in the journal:**

Dr. Tom Crist, *Miami University*

Dr. Bob Parmenter, *Valles Caldera Trust, New Mexico*

Dr. Heather Bateman, *University of New Mexico*

Dr. Chrissa Stroh, *National Oceanic and Atmospheric Administration*

Mr. Murray Laubhan, *Kansas Department of Wildlife & Parks*

Dr. Mary Harner, *University of New Mexico*

## **Forest Service**

Tom Tidwell, *Chief*

Ann Bartuska, *Deputy Chief, Research and Development*

Jim Hubbard, *Deputy Chief, State and Private Forestry*

John Sebelius, *Staff Director, Science Quality Services*

Safiya Samman, *Staff Director, Conservation Education*

Rob Doudrick, *Staff Director, Resource Use Science*

Greg Arthaud, *Research Social Scientist, Resource Use Science*

## **U.S. Geological Survey**

Marcia McNutt, *Director*

Suzette Kimball, *Deputy Director*

D. Bryant Cramer, *Associate Director for Geography*

Ione L. Taylor, *Chief Scientist for Geography*

Susan D. Haseltine, *Associate Director for Biology*

K. Bruce Jones, *Chief Scientist for Biology*

Carl Shapiro, *Chief, Office of Science, Decisions, and Resource Management*

With thanks to:

*Cradle of Forestry Interpretive Association*

Alex Comfort, *Executive Director*

Bill Alexander, *Chairman*

Rita Brown, *Forest Service Conservation Education Coordinator*

Dianna Hogan, *U.S. Geological Survey*

Project Learning Tree

<http://www.plt.org>



# Editorial Review Board

## student Editorial review Board Comments



Janet Johns' 7th grade classes, Cass Middle School, Cartersville, Georgia

*"I think you should put more pictures in to make the article more interesting."*

*"This is pretty cool because it's about someone going out and having fun with earth and water stuff."*



*"The pictures help explain things, so it is not just words."*

*"I like this glossary. It makes the words more clear."*



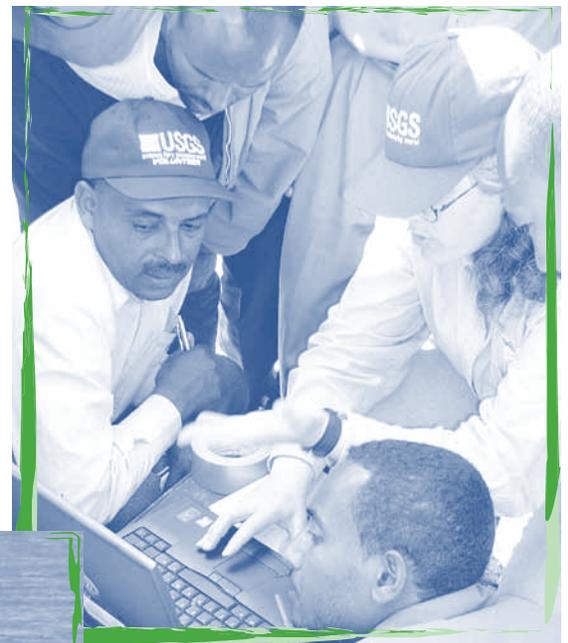
# Contents

- 3 Editorial Review Board
- 5 About the *Natural Inquirer*
- 5 Who Are Scientists?
- 6 Welcome to the Ecosystem Services Edition of the *Natural Inquirer*!

## Features

- 10 **Toad-ally Awesome! Investigating the Relationship Between Flooding and Toad Reproduction Along the Rio Grande**
- 20 **What Goes Around Comes Around: How Long-Term Weather Patterns Affect Plants in Carolina Bay Wetlands**
- 32 **Think Outside the Box: Predicting the Spread of Invasive Species**
- 40 **Fill Those Potholes! Identifying Ecosystem Services of Small Wetlands on the American Prairie**
  
- 52 Crossword Puzzle and Word Search
- 54 Note to Educators
- 55 Lesson Plan
- 64 National Science Education Standards for the Ecosystem Services Edition of the *Natural Inquirer*

- Inside back cover What is the Forest Service?
- Inside back cover What is the U.S. Geological Survey?
- Back cover Editorial Review Board
- Back cover Web Sites



# About the Natural Inquirer

Scientists report their research in journals, which are special booklets that enable scientists to share information with one another. This journal, the *Natural Inquirer*, was created so that scientists can share their research with you and with other middle school students. Each article tells you about scientific research conducted by scientists in the U.S. Department of Agriculture (USDA) Forest Service. If you want to know more about the Forest Service, you can read about it on the back cover of this journal, or you can visit the *Natural Inquirer* Web site at <http://www.naturalinquirer.org>.

All of the research in the *Natural Inquirer* is concerned with nature, such as trees, forests, animals, insects, outdoor activities, and

water. First, you will “meet the scientist” who conducted the research. Then you will read something special about science and about the natural environment. You will also read about a specific research project. This is written in the format that scientists use when they publish their research in journals. Then, YOU will become the scientist when you conduct the FACTivity associated with each article. Don’t forget to look at the glossary and the special sections highlighted in each article. These sections give you extra information.

At the end of each section of the article, you will find a few questions to help you think about what you have read. They should help you to think more about the research. Your teacher may use these questions in a class discussion.

## 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 environmental scientist, you must:



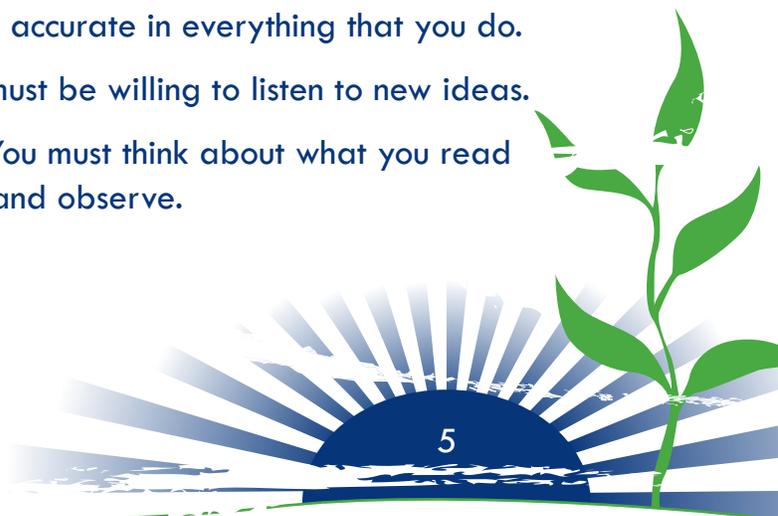
**Be curious** – You must be interested in learning.

**Be enthusiastic** – You must be interested in an environmental topic.

**Be careful** – You must be accurate in everything that you do.

**Be open minded** – You must be willing to listen to new ideas.

**Question everything** – You must think about what you read and observe.



# Welcome to the Ecosystem Services Edition of the Natural Inquirer!



Have you ever heard the term “ecosystem services?” Can you imagine what ecosystem services might be?

Ecosystem services are provided by healthy natural areas just because they are healthy natural areas. Ecosystem services are valued by people, even if people do not always think about where these services come from. Examples include clean air, clean water, beautiful landscapes, healthy soil, places for wildlife to live, minerals, and even places to do outdoor activities. Even pollination is considered an ecosystem service because pollination is important to the production of food.

Ecosystem services are important because they provide goods and services that are vital to human health and quality of life. Ecosystem services are life-support systems for plants, animals, and humans worldwide. Some ecosystem services are called “public goods” because they are available to everyone (such as clean air). The process of waste decomposition and carbon storage are more examples of ecosystem services.

Scientists have studied ecosystems for a long time. The concept of ecosystem services, however, is relatively new. The identification of ecosystem services allows scientists to let

people know that ecosystems are important to everyone. Some people value ecosystem services for the wildlife they support, while others may have greater appreciation for services such as food or energy production. Everyone benefits from ecosystem services, and the prosperity of humans, past, present, and future, is dependent upon healthy ecosystems.

Although it is difficult to put a price on clean air, for example, scientists have begun to look at the monetary value of ecosystem services. When the monetary value of ecosystem services is not known, the ecosystem may be destroyed in favor of something on which we can place a price. For example, when a forest is destroyed so a building can be built, the forest no longer provides the ecosystem service of holding carbon, providing homes for songbirds, or cleaning the air. By identifying and placing a value on ecosystem services, people are able to make better decisions.

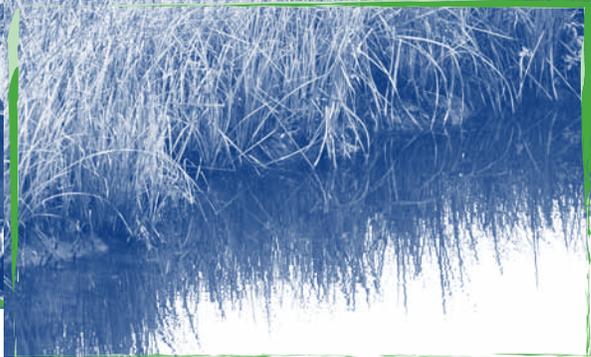
In this edition of the *Natural Inquirer*, you will learn new and different things about ecosystem services. Then you can look around you and identify the services being provided to you and your community by the natural world!



# What are Ecosystem services?



Resurrection Bay, Alaska: Bare rock provides a place for animals to bask in the sun.



Marsh west of Jekyll Island, Georgia: Wetlands provide habitat for many animals and filter pollutants from the water.



Ben Eidge National Nature Reserve, Scotland: Natural resources provide areas for people to enjoy the outdoors.



Bentonville, Arkansas: Some animals, including some insects, birds, and bats, are pollinators. Pollination is essential for the reproduction of fruits, vegetables, and flowers.



Berkeley Springs, West Virginia: Trees act as umbrellas by catching rain drops. This decreases the amount or slows the rate of water reaching the ground, and helps to reduce soil erosion and flooding.



Hard Labor Creek State Park, Georgia: Decaying leaf litter helps to build the soil and provides a home for animals. Animals, such as snakes, are part of a healthy ecosystem.



Holgate Glacier, Aialik Bay, Alaska: Glaciers provide a continual source of fresh water. Scientists study glaciers for clues about Earth's natural history.



Near Salzburg, Austria: Forests provide many ecosystem services. They provide homes for animals and plants, resources for people, help to reduce the impact of global climate change, clean the air, and provide clean water.



# What is Geography?

Geography is the study of Earth, its land, and its **inhabitants**. A geographer studies places where life is found and the way living beings interact with their Earth home. In this *Natural Inquirer*, you will learn about how geographers study ecosystems as special places and how people, other animals, and plants interact with and gain value from ecosystems.

Scientists with the United States Geological Survey, or USGS, often use satellites to study geographic questions on Earth. Satellites continually orbit Earth, collecting information about our planet (**figure 1**). For example, USGS scientists use information from satellites

## Glossary

**inhabitant** (in **hab** uh tent):  
One who occupies a particular area.

to track the dates that leaves unfold in spring and fall off of trees in autumn. This helps them to identify how changes in an area's climate affect the growth of trees. Information from satellites has also been used to create a map that shows the types of ecosystems found in the United States. This map will help scientists better understand the types and values of the ecosystem services provided.

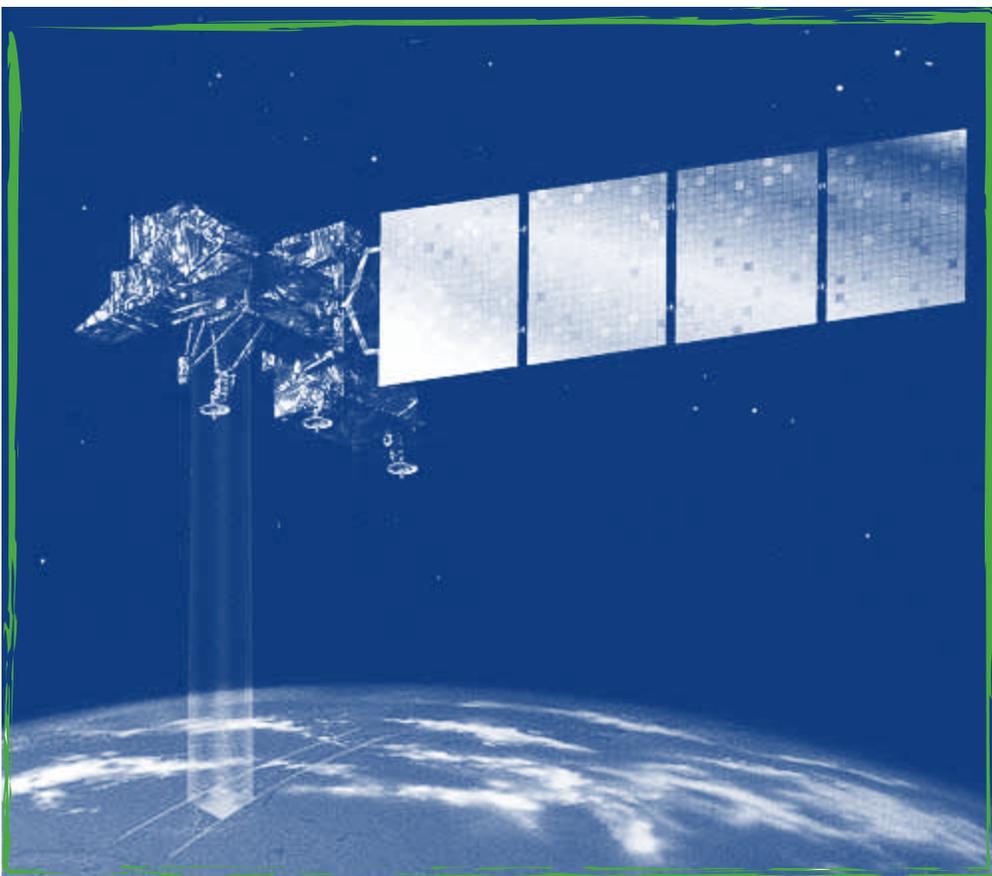


Figure 1. Landsat satellite orbiting Earth. Photo courtesy of NASA

USGS geographers also do research within ecosystems themselves. One place these geographers are studying is the Everglades. This is a large wetland area running through the middle of south Florida. Wetlands are areas of land that are sometimes covered by water, and often they are beside areas of water. Wetlands provide many ecosystem services to people including clean water, clean air, and natural places for many animals and plants to live.



Figure 2. Dr. Bill Labiosa helps people think about the different effects that decisions have on alligators in the Everglades. Unless you are a scientist studying alligators, remember not to get close to an alligator!

Because the Everglades provides a variety of ecosystem services, it is important to make good decisions about how it is managed. USGS geographers have created a computer program that uses maps to help get the most out of the ecosystem services provided by the Everglades (figures 2, 3, and 4).



Figure 3. Dr. Dianna Hogan studies the way people use land in the Everglades, and how that affects the ecosystem services they receive. She especially likes to study plants and animals. This Double-crested Cormorant (next to Dr. Hogan) catches fish in the Everglades using its hooked bill.

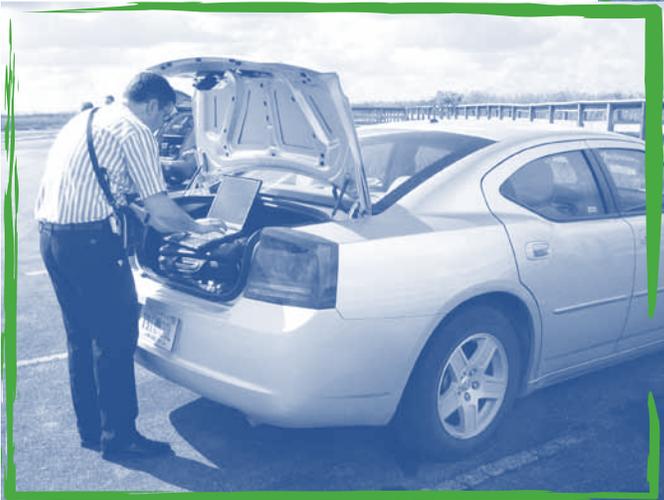
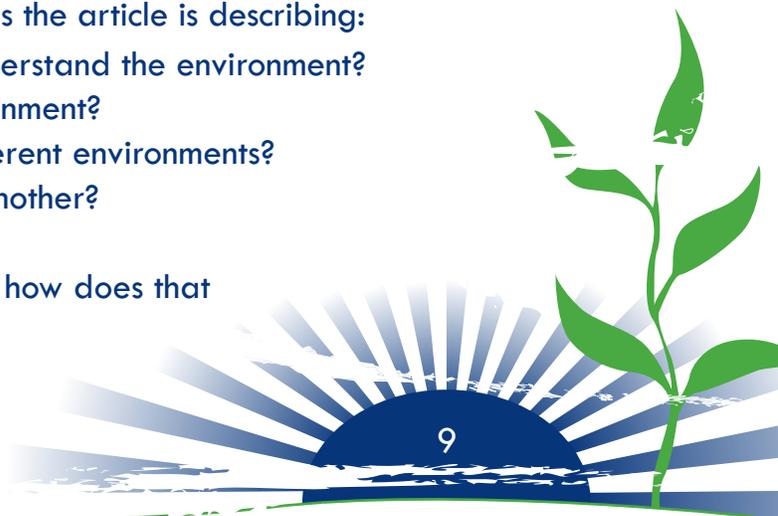


Figure 4. Mr. David Strong provides the computer and GIS (Geographic Information System) computer program that allows the scientists to answer their questions. Here, Mr. Strong works on his computer from the trunk of his car.

As you read this *Natural Inquirer*, think about geography and how it helps people to better understand and protect our planet. As you read each article, identify which of the following geography questions the article is describing:

- How do maps and images help us better understand the environment?
- How do life forms behave in their own environment?
- How do life forms behave differently in different environments?
- How do life forms move from one place to another?
- How do life forms change the environment?
- How do people change the environment and how does that affect other life forms?
- How are places different?
- How are different places similar?



# Toad-ally Awesome!



Investigating the Relationship Between  
Flooding, Summer Rains, and  
Toad Reproduction Along the Rio Grande

# Meet the Scientists

**Dr. Heather Bateman:** My favorite science experience has always been working with wildlife. I enjoyed placing leg bands on long-eared owls in the United States Great Basin. I also enjoyed tagging lava lizards on the Galapagos (ga **lop** uh gos) Islands. One day, I spent over 12 hours measuring and weighing hundreds of toadlets, or small toads. They had been laid as eggs in pools of water in a riparian (ri **pair** e an) forest after a spring flood. A riparian forest is a forest located next to a body of water. Later, the frogs underwent **metamorphosis**, developing from tadpoles to toadlets. They fell into traps that we used to count and release them. The toadlets were about the size of my thumbnail.



**Dr. Mary Harner:** My favorite science experiences are conducting field research along rivers and in the tropics. Recently, I have had the fortune to study the ecology of bats on the island of Trinidad, located off the coast of Venezuela, as well as the ecology of plants along rivers in North America and in Europe. I enjoy being outdoors, studying organisms in their natural environments, and working with groups of scientists who have a broad knowledge of nature.



**Dr. Alice Chung-MacCourbrey:** My favorite science experience was a research project that allowed me to combine two of my biggest interests, dogs and bats. Dogs have a superb sense of smell that can be used in wildlife research. My dog used to accompany me in the field while I was radiotracking bats to find their tree roosts, and it was clear that she could smell the bats. In summer 2006, I tested my hypothesis that dogs could be used to locate bat roosts and conducted field tests using professionally trained scent detection dogs to locate bat tree roosts (by finding guano piles which are piles of bat poop). The dogs sniff out the guano. When they find the guano they sit by the tree and are rewarded with a short game of fetch.

### Glossary

**metamorphosis** (met uh môr fuh sis):

The process of changing in form, for some animals, from an immature stage to an adult stage.

**migratory** (mî gruh tôr ě):

Having a characteristic of moving from one place to another on a periodic basis.

**regulation** (reg ũ la shun):

Bringing under control of law or some authority.

**flood plain** (fluhd plan):

Flat land area next to a stream or river.

**headwaters** (hed wa türs):

The upper streams that contribute water to another source of water such as a river.

**semi-arid** (sem ĩ air id):

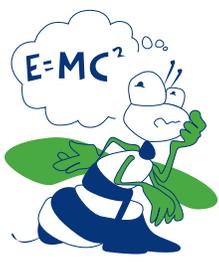
An area that receives very little rainfall.

### Pronunciation Guide

<u>a</u>	as in ape
ä	as in car
<u>e</u>	as in me
<u>i</u>	as in ice
<u>o</u>	as in go
ô	as in for
<u>u</u>	as in use
ü	as in fur
<u>oo</u>	as in tool
<u>ng</u>	as in sing

Accented syllables are in bold.



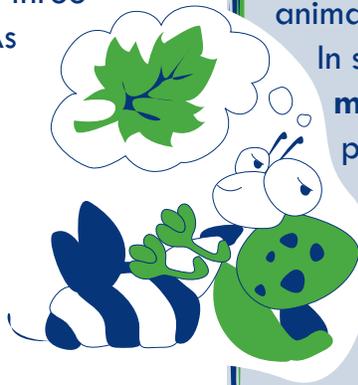


## Thinking About Science

Taking measurements is a common practice in everyday life. Most scientific experiments involve units of measurement. Units of measurement are things like inches or centimeters, miles or kilometers per hour, ounces or grams, or frequency. A scientist may want to know, for example, how many times a Screech owl visits a particular Red Oak tree during the summer. In that case, the unit of measurement is frequency. Think of three things you have measured today. As you read the “Introduction” section of the article, make a guess as to what the scientist will measure in the research. Identify what unit of measurement was used.

## Thinking About the Environment

Think about what it takes for you to survive everyday. Aside from food and water, humans need clothing and shelter. If adults are raising a family, they must provide for their families as well. Animals must also have certain things to survive. They need a place to live, things to eat, and a place to reproduce. The environment in which a species lives is called its habitat. In the study you are about to read, scientists wanted to learn about the best habitat for toads to reproduce. While reading the article, identify how humans impact the habitat of toads. Remember that humans have both positive and negative effects on an animal’s habitat.

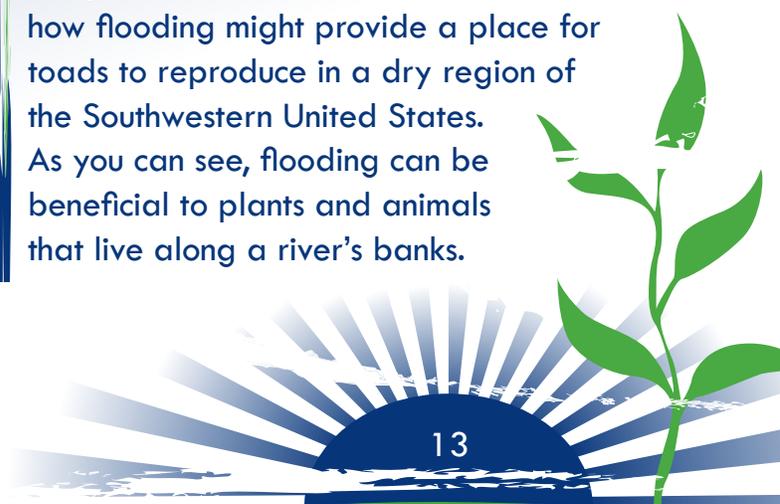


## Floods – Friend or Foe?

When you hear about flooding in the news, it seems as if flooding is not a good thing. Floods, however, can be beneficial to many types of animals and plants. Rivers carry sediment and nutrients in their waters. When flooding occurs, the sediment and nutrients are deposited on the land next to the river. The flooding helps to enrich the soil. The nutrient-rich soil is a good thing for the plants that live there. If plants benefit from flooding, the animals that live there will benefit also.

In some places, flooding is a signal for **migratory** fish to migrate. Flooding provides a way for separate bodies of water to connect for a while, which provides an opportunity for native animals and plants to move to new environments.

Flooding is also a natural way of helping some plant and animal species reproduce and survive. For example, frogs and toads are tadpoles before they develop into adult frogs and toads. To develop into adults, tadpoles require water. In fact, frogs and toads must also have water to lay their eggs. In this study, the scientists were interested in how flooding might provide a place for toads to reproduce in a dry region of the Southwestern United States. As you can see, flooding can be beneficial to plants and animals that live along a river’s banks.



# Introduction

Most rivers in the United States are now regulated. A regulated river is one whose flow is controlled by dams. For people, the **regulation** of rivers provides protection from flooding, as well as reliable sources of water for drinking and cooking, farming, and industry. The regulation of rivers, however, alters the relationship between rivers and their **floodplains**. When a floodplain floods, the water provides a needed habitat for some animal and plant species. Floodplains may also flood after rains occur downstream from the dam. When dams are built in river systems, however, wet floodplain habitats are less available.

The scientists in this study were interested in studying how toads reproduce in the floodplains along the Rio Grande. The Rio Grande is a river that flows from its **headwaters** in southern Colorado for 1,865 miles to the Gulf of Mexico near Brownsville, Texas (**figures 1 and 2**). The Rio Grande is regulated by four dams that control the river's flow (**figure 3**). The scientists studied a section of the Rio Grande in a **semi-arid** area in New Mexico that could occasionally flood. The question the scientists wanted to answer was this: How does flooding affect the reproduction of toads in the forests, or the bosque, along the Rio Grande?

Figure 3. One of the dams on the Rio Grande. The lake created by the dam is on the right. The Rio Grande is on the left.



Figure 1. The Rio Grande from southern Colorado to the Gulf of Mexico. The Rio Grande is the border between the State of Texas and country of Mexico.



Figure 2. The Rio Grande. The United States is on the right and the country of Mexico is on the left. In some areas, the Rio Grande still occasionally floods. Notice the strip of green vegetation along the river banks. This is the Rio Grande's forested floodplain. Along the Rio Grande, the forested floodplain is called the bosque (bosk or bos-key).



## Reflection section

- What was the question the scientists wanted to answer?
- How do you think flooding affects the reproduction of toads?

## Method

The scientists collected data from June through September 2000 to 2006. They monitored 12 sites in the bosque along 140 km of the Rio Grande in New Mexico (see **figure 1**). The scientists used pitfall traps (**figure 4**) and drift fences (**figure 5**) to capture toads at each site. They counted and weighed the toads and then released them.

The scientists also measured other things at each of the 12 sites. They recorded the amount of rainfall over the 7 years. They measured the amount of water flow in the Rio Grande. They also measured the level of the groundwater in the bosque.

Figure 4. Pitfall trap

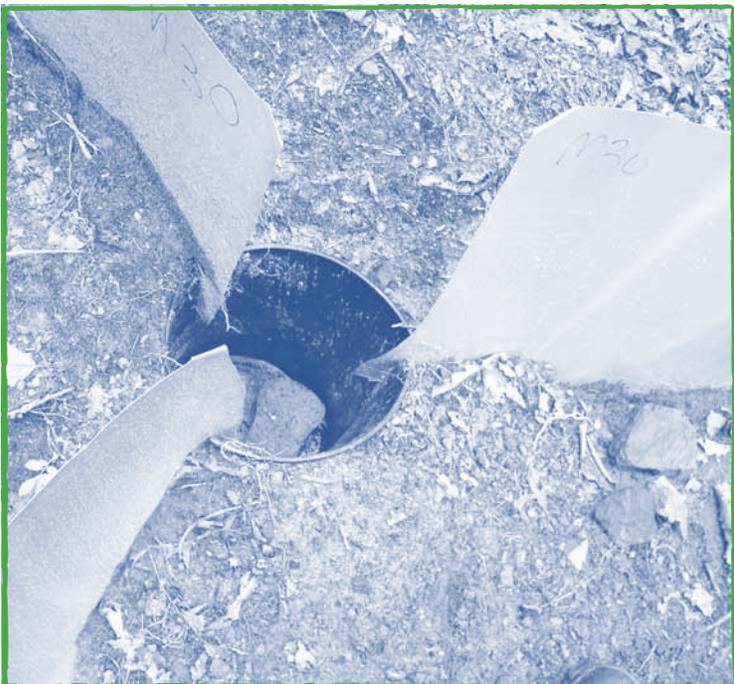


Figure 5. Drift Fence

## Number Crunches

How many miles is 140 km? (km is an abbreviation for kilometers) To find out Multiply 140 km by .621.

## Reflection section

- Why did the scientists also measure the amount of rainfall and the amount of water flow at each of the sites?
- Why do you think the scientists conducted their experiment from June through September of each year?

# Findings

The scientists found that rainfall varied over the 7 years. In some years there was little rainfall, while in others there was a lot of rainfall. For most of the years, the scientists did not capture many toads. In 2005, however, two of the sites flooded. At those sites, the scientists captured many more toads (**figure 6**). Most of the toads captured in 2005 were small (compare **figures 7 and 8**). This told the scientists that there were many young toads at the two flooded sites.

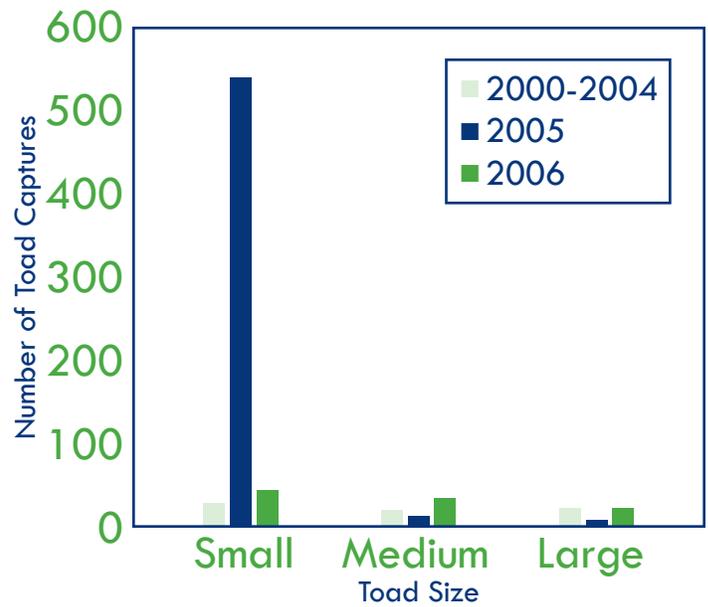


Figure 6. The average number of toads captured each month at all sites over 7 years.



Figure 7. Small Woodhouse's toad



Figure 8. Adult Woodhouse's toad

## Reflection Section

- Look at figure 6. Do you think flooding affected the reproduction of toads? Why or why not?
- What other living things do you think might be affected by flooding? Why?

# Discussion

The scientists concluded that the capture of many small toads in the flooded areas meant that adult frogs had used the flooded areas for breeding. Since the Rio Grande is a regulated river, floods are no longer common. The scientists believe that purposely flooding the bosque at certain times would provide areas for toads to breed. These small floods could be safely managed to protect both people and the population of toads that live in the bosque.



## Reflection section

- Do you think it would be a good idea to purposely flood the bosque periodically? Why or why not?
- Would people benefit from flooding that would enable the toads to reproduce? Why or why not?

This article was adapted from Bateman, H.L.; Harner, M. J.; and Chung-MacCoubrey, A. (2008). Abundance and reproduction of toads (*Bufo*) along a regulated river in the southwestern United States: Importance of flooding in riparian ecosystems. *Journal of Arid Environments*. 72: 1,613-1,619. <http://hbateman.faculty.asu.edu/Publications>.

# Toad-ally Awesome Word Search

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

1. Flat land area next to a stream or river.
2. The upper streams that contribute water to another source of water such as a river.
3. The process of changing in form, for some animals, from an immature stage to an adult stage.
4. Having a characteristic of moving from one place to another on a periodic basis.
5. Bringing under control of law or some authority.
6. An area that receives very little rainfall.



# FACTivity

Teachers may use the lesson plan at the back of this journal to guide student reading of the article.

**Time Needed:** Two class periods.

**Materials Needed:**

- “Toad-ally Awesome” article
- “Swimming Upstream Without a Ladder” article (You may download and print this article or order it from the *Natural Inquirer* Web site <http://www.naturalinquirer.org/Dams-and-Pipes-and-River-Shrimp-Movementsa-11.html>)
- Paper
- Pencils

You learned in this article that flooding can provide a service to the toads living along the Rio Grande in New Mexico. When flooding occurs in the spring, wet areas are created that provide places for toads to reproduce. In this FACTivity, you will answer these two questions:

- 1. What are the similarities of and differences between flooding in the bosque and the flow of mountain streams in Puerto Rico?**
- 2. How do the ecosystem services provided by these two waterways compare?**

The method you will use to answer these questions is:

Following the reading of the article: Make sure that everyone in your class has read and understands the “Toad-ally Awesome” article. In a rapid-fire exercise with the entire class, make a list of as many ecosystem services (or benefits) provided by the bosque as you can. Try to use your imagination to come up with benefits that may not have been discussed in the article. Put this list on the wall where it can be used during the next class period.

Next class period: Following the same procedure used to read “Toad-ally Awesome,” read “Swimming Upstream Without a Ladder.” Organize into groups of 3 to 4 students. Each group of students will compare and contrast the two articles.

Use the list of benefits identified earlier. Record similarities and differences using the chart on the next page.

Each group should share their findings with the class. Hold a discussion about the ecosystem services or benefits provided by waterways. Brainstorm other ecosystem services provided by waterways. Students should put their names on their charts and turn them in to the teacher. The teacher can use these charts as an assessment tool.

Extension: Research waterways in your area and identify how those waterways benefit the plants and animals that live near them.

	Describe (One sentence for each waterway)	Similarities	Differences
The Waterway			
The Land			
The Animal Being Studied			
The Climate			
The Dams			
Benefits Provided by the Waterway			



If you are a Project Learning Tree-trained educator, you may use PLT Activity #94, "By the Rivers of Babylon," PLT Activity #9, "Planet Diversity," and PLT Activity #29, "Rain Reasons" as additional resources.

**Additional Web Resources:**

USGS's Woodhouse's Toad Page

<http://www.npwrc.usgs.gov/resource/herps/amphibid/species/bwood.htm>

National Park Service's Rio Grande Web Page

<http://www.nps.gov/rigr/>



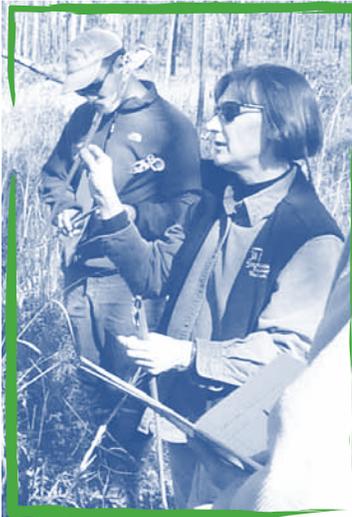


What Goes Around Comes Around:  
How Long-Term Weather Patterns  
Affect Plants in Carolina Bay Wetlands



# Meet the Scientists

**Ms. Chrissa Stroh, Coastal Ecologist:** I have wonderful science experiences every day! Watching the sun rise, seeing birds fly overhead, or observing the neat shapes of flowers and leaves on plants outside. One of my favorite science experiences was visiting the Volcano Arenal (är ah nul), an active volcano in Costa Rica. I was there as the sun was going down, and was able to see and hear red-hot lava rocks tumbling down the sides of the volcano.



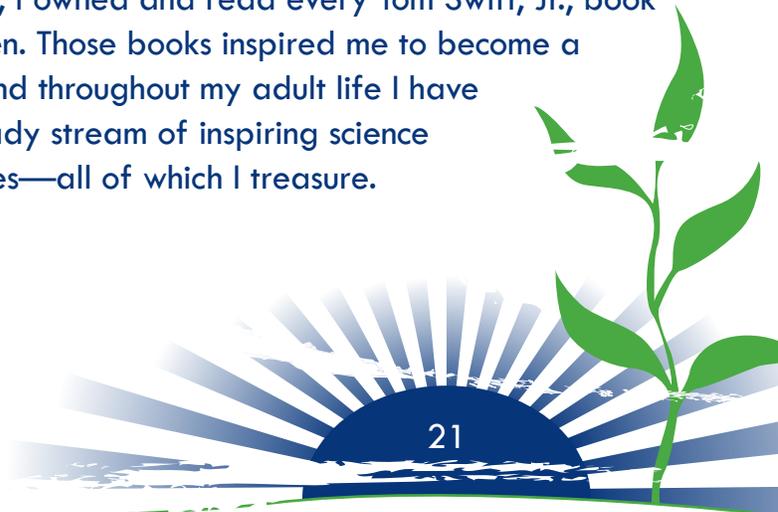
**Dr. Diane De Steven, Wetland Plant Ecologist:** My favorite science experience is working in the field and observing the plants and animals of different

habitats. I can get a break from city noises, hear the quiet sounds of nature, and appreciate the great diversity of life. My research has

allowed me to visit tropical rainforests, prairies, mountain forests, deserts, and (of course) many types of wetlands.



**Dr. Glenn Guntenspergen, Landscape Ecologist:** As a young boy, I owned and read every Tom Swift, Jr., book ever written. Those books inspired me to become a scientist, and throughout my adult life I have had a steady stream of inspiring science experiences—all of which I treasure.



## Glossary

**classification** (cla suh fuh **ka** shun): A method used by scientists to group or categorize species of organisms.

**vegetation** (ve juh **ta** shun): Plant life.

**wetland** (**wet** lend): Areas of land with a lot of soil moisture.

**aquatic plants** (uh kwat ik plants): Plants growing or living in or upon water.

**marsh plants** (märsh plants): Plants growing in dry areas outside wetlands.

**woody plants** (**wood** e plants): Plants growing in dry areas outside wetlands in the ecosystem.

**freshwater** (fresh **wä** tür): Water source that has low amounts of salt concentration.

**ecosystem services** (e ko sis tem **sür** vis es): Environmental health benefits provided by a community of plant and animal species.

**drought** (drowt): A period of dry weather with little or no rain.

**ecosystem** (e ko sis tem): Community of plant and animal species interacting with one another and with the nonliving environment.

**model** (**ma** del): A simplified example of a system in science.

**cyclical** (sik kli kül): Occurring in a pattern that typically happens again and again.

**indicator** (in di **ka** tôr): Something that symbolizes something else.

**sample** (sam pul): A small part of a group.

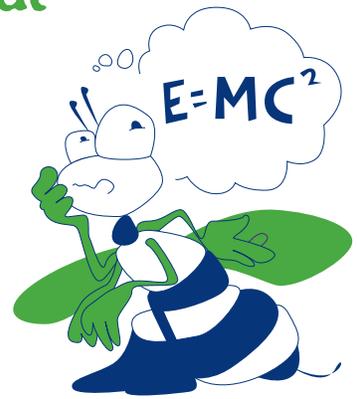
**annual** (an **u** ul): Occurring every year.

**concentric** (kän **sen** trik): Having a common center.

**population** (päp **yoo** **la** shun): The whole number of individuals of the same type occupying an area.

## Thinking About Science

When scientists want to solve a problem, they collect information to understand the problem. To understand the information, scientists sometimes use a technique called **classification**. Classification helps scientists group and categorize many things into simpler groups. This technique can create groups that can be compared to each other. For example, if someone gave you a bag of



## Pronunciation Guide

<b>a</b>	as in ape
<b>ä</b>	as in car
<b>e</b>	as in me
<b>i</b>	as in ice
<b>o</b>	as in go
<b>ô</b>	as in for
<b>u</b>	as in use
<b>ü</b>	as in fur
<b>oo</b>	as in tool
<b>ng</b>	as in sing

Accented syllables are in bold.

coins, would it be easier to count the coins one by one? Or would it be easier to put the pennies with each other, the quarters with each other, and so on? It is much easier to count the money by classifying it rather than counting the coins one by one.

In this study, scientists classified **vegetation** in and around **wetlands**. The scientists classified the plants into three groups: **aquatic plants, marsh plants,** and **woody plants**. Aquatic plants include plants like water lilies that are found growing in water. Marsh plants, like grasses, can grow in shallow areas between deeper water and dry areas. Woody plants, like trees and shrubs, are plants that live in dry areas outside wetlands. This type of classification helps scientists to simplify and compare the data they collected in the study area.

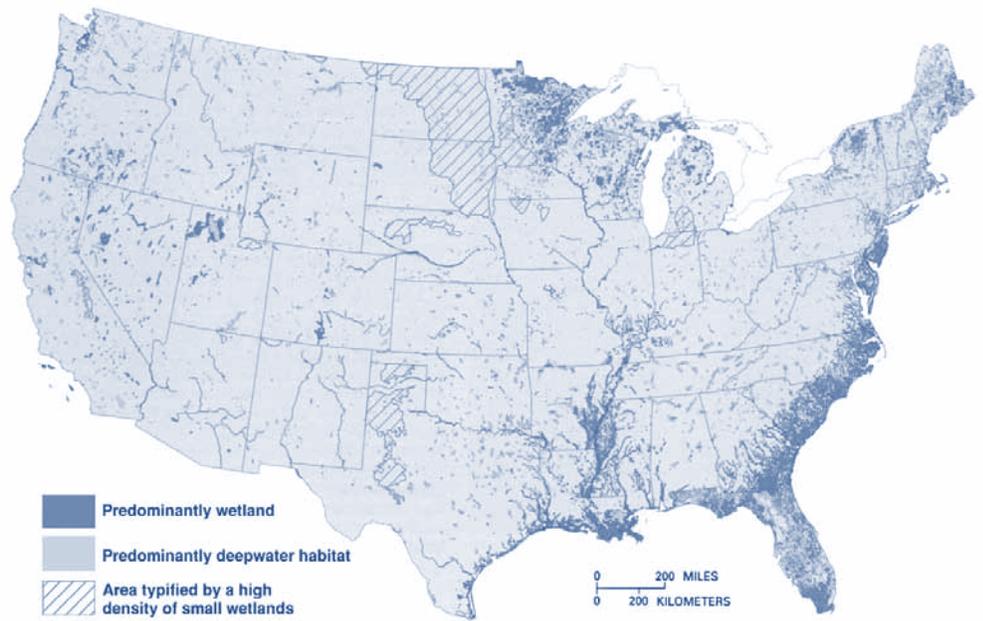


Figure 1. Wetlands of the United States of America. Image created by Robert H. Yuhus of the United States Geological Survey.

floods occur. Water is held in the wetland rather than flooding people's homes and cities. These wetlands are also homes and breeding areas for many different types of wildlife – For example, ducks, frogs, salamanders, beavers, fish, alligators, and many more. Freshwater wetlands depend on rainfall to stay wet. When a **drought** occurs, the water levels drop. Sometimes the wetland dries up all the way. If there is not enough water in the wetland, then this can change how the wetland does its job in the ecosystem. The scientists in this study were interested in how different amounts of rainfall affect wetlands.



Why should we care about **freshwater** wetlands? Freshwater wetlands play an important role in an ecosystem by providing **ecosystem services** throughout the world (**figure 1**). Freshwater wetlands help clean the water by removing pollution. They act like a storage unit when



# Introduction

Shallow land depressions can be found within some forests of the United States. These depressions are filled by rainfall, particularly in the spring when the rains are most frequent. In certain areas of the Southeastern United States, these wet depressions are called Carolina bays (figure 2). Throughout the

up is called a hydroperiod (**hi** dro **per** e ud). When these bays have water, aquatic plants grow in the water, and marsh plants or woody plants grow along the wet edge of the wetlands (figure 3). A Carolina bay is a freshwater wetland.

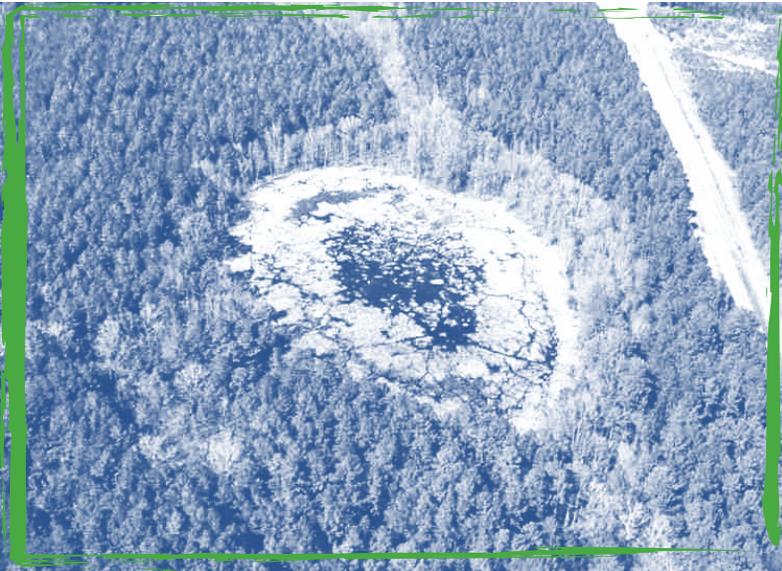


Figure 2. A Carolina bay.

summer months, Carolina bays dry up as rain becomes less frequent and the temperature increases. The period from when the Carolina bays are filled by rain to the time they dry



Figure 3. A Carolina bay filled with water and aquatic plants.

What does hydro mean? “Hydro” can be a part of many different words, but it always relates to water (figure 4). Knowing what hydro means can help you understand what the whole word means. For example, *hydrology* means the study of water. Dehydrate means loss of water for normal body function. What do you think *hydropower* means?



Figure 4. The energy created by damming waterways is called hydropower.

You may recall that freshwater wetlands provide a lot of benefits. (See “Thinking About the Environment.”) The scientists in this study were interested in whether prolonged periods of drought may enable trees and other woody plants to grow into the wetlands during the long dry periods. If that happened, the wetlands could change into a forested wetland (swamp.) This is called the **directional model**. It is called directional because the bays would change in only one direction. Think about how people develop and change. Think about how people change from being a baby to child to teenager to adult. People do not go from baby to teenager to baby to teenager to adult. Human development represents a directional model.

Other scientists proposed that Carolina bays could survive long periods of drought. This is called the **cyclical model**, because in this model the bays always return to their aquatic ecosystem.

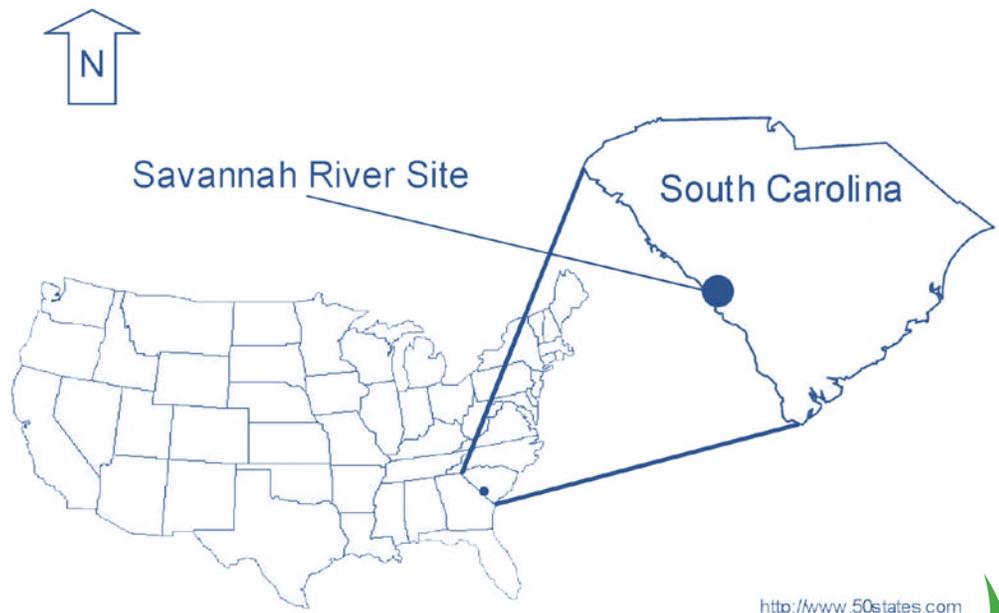
Those scientists, however, had only studied Carolina bays for short periods of time. The scientists in this study wanted to study Carolina bays over a longer period of time. The question they wanted to answer in this study was: Over a long period of time following periods of drought, do Carolina bays become more forested or do they always return to their aquatic ecosystem?

## Reflection section

- What would happen to the Carolina bays if the directional model were correct? What would happen if the cyclical model were correct?
- What question did the scientists ask?

## Method

The research was conducted in an area in the Savannah River Site in South Carolina along its border with Georgia in the Southeastern United States (**figure 5**). The scientists identified seven Carolina bays in this area. In the spring, each of these bays was filled with water. The smallest bay was 4.5 hectares and the largest was 12 hectares.



<http://www.50states.com>

Figure 5. The study area was located in the Savannah River Site in South Carolina along its border with Georgia in the Southeastern United States.



## Number Crunches

How many acres were the smallest and largest bays? Hint: Multiply the number of hectares by 2.47 to find out.

To answer their question, the scientists decided to use the type of vegetation and the depth of the water as **indicators**. To measure water depth, the scientists used a water gauge (**figure 6**). The water gauge also helped the scientists to measure hydroperiod.



Figure 6. Water gauge in a forested swamp.

The bays were too large to identify all of the plants growing in them. To decide where in each bay the scientists would identify plants, they developed a special system to **sample** the vegetation. The scientists placed a post in the middle of each Carolina bay. They connected eight cables to the center post. Each cable was pulled out to the edge of the bay and connected to a post at the water's edge. The cables were evenly spaced. Each cable was marked every 10 meters (**figure 7**).

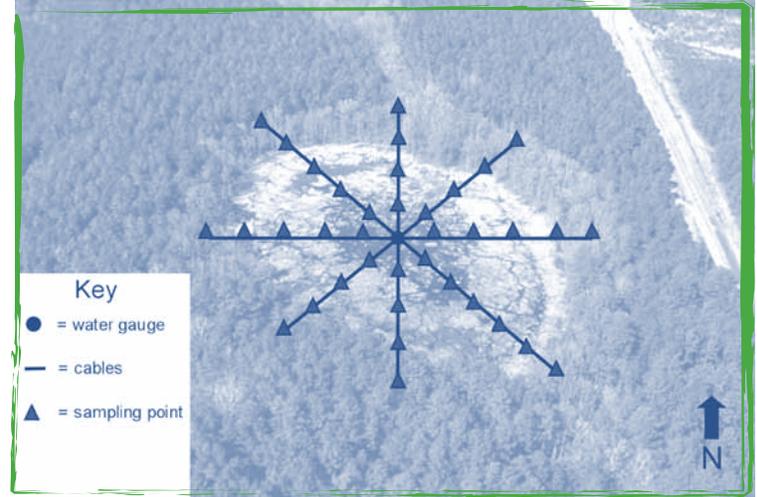


Figure 7. Diagram of the sampling method.

## Number Crunches

How many yards apart were the cables marked? Hint: Multiply 10 meters by 1.09 to find out. How many feet apart were the cables marked?

Scientists recorded the types of plants growing under the eight cables in the places that had been marked. (See Ms. Stroh's photo, page 21.) They then classified the vegetation into three types, depending on how much water the plant needed to survive. The types were aquatic plants, marsh plants, and woody plants (**figure 8**).

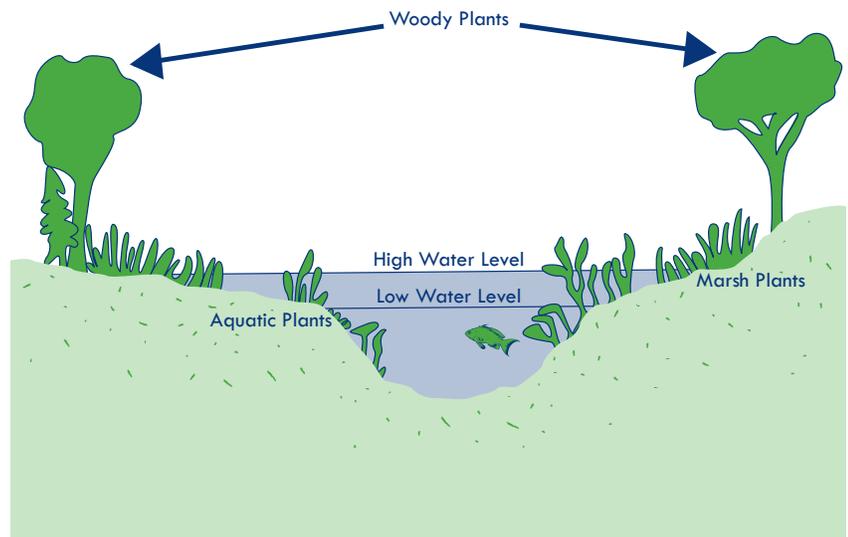


Figure 8. Examples of the three types of vegetation identified by the scientists.

## Number Crunches

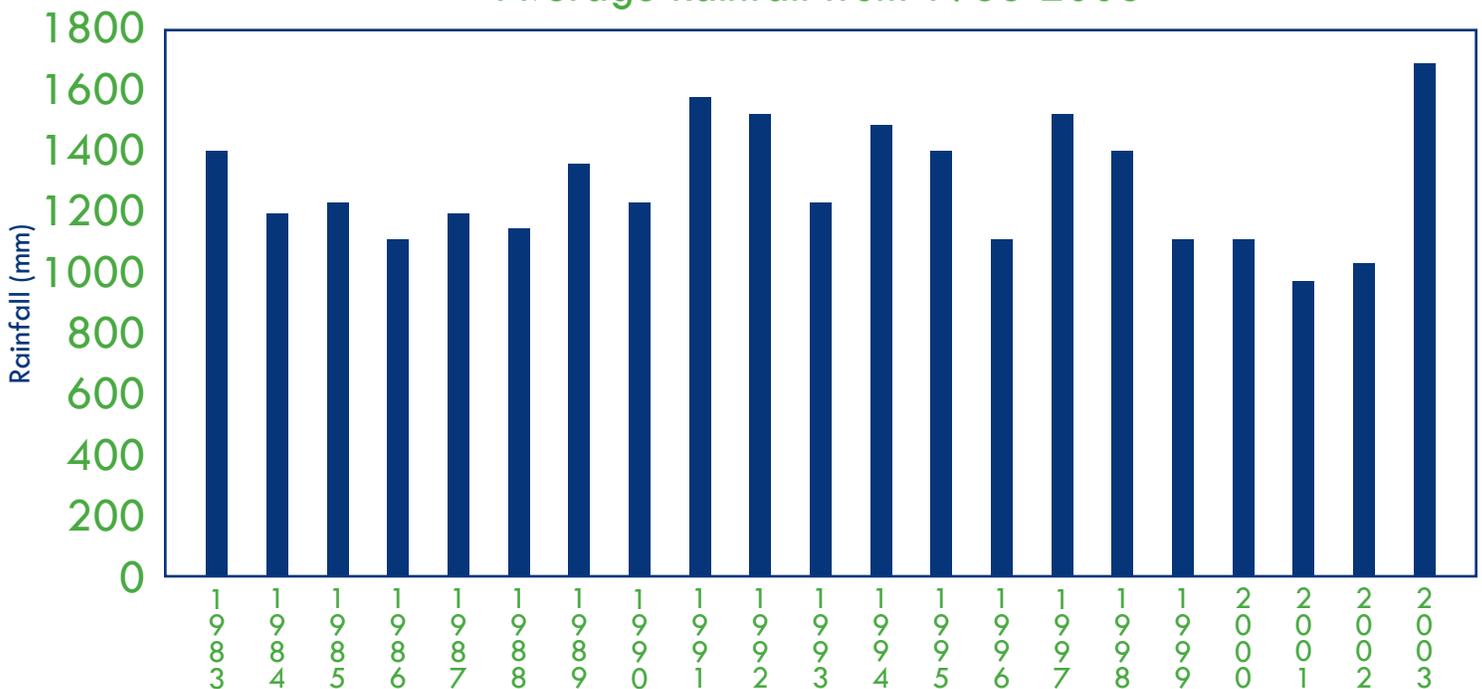
Although the bays were not a perfect circle, you could draw an imaginary circle with the post as the center (see **figure 7**). You know that a circle has 360 degrees. If the eight cables were evenly spaced, how many degrees apart was each cable?

The scientists also collected information about **annual** rainfall (**figure 9**). This way, they could identify times of drought. The scientists collected information about water depth and vegetation in the summers from 1983 to 2003. They also recorded the hydroperiod of each bay for every year.

## Reflection section

- How do you think changes in rainfall affected the aquatic plants, marsh plants, and woody plants around the wetland?
- An ecosystem is a very fragile system. When something disrupts the balance, the ecosystem may take years to recover. Do you think rainfall only affects vegetation in the current year or can rainfall affect how vegetation grows the next year? Explain.

## Average Rainfall from 1983-2003



The scientists then compared the amount of rainfall, water depth, and hydroperiod with the type of vegetation growing in each Carolina bay. They did this over a 15-year period, paying close attention to what happened to the vegetation after a period of drought.

Figure 9. Average annual rainfall at the Savannah River Site from 1983 to 2003.



# Findings

The scientists found that over a long period of time, the bays' vegetation patterns show a cyclical model rather than a directional model. The scientists also found that vegetation patterns were influenced by current-year rainfall and last year's rainfall. It can take up to a year for the water in a bay to recover from a drought period (**figure 10**)!

The scientists discovered that when the bays were the driest, the fewest amounts of aquatic plants were found because of the low water levels in each bay. Instead, woody and marsh plants could grow and expand into the wetland. When the rains returned, the vegetation started to change again. During this recovery period, the deeper water caused woody and marsh plants to decrease. Once the bays contained a lot of water, the aquatic plants appeared again (**figure 11**).

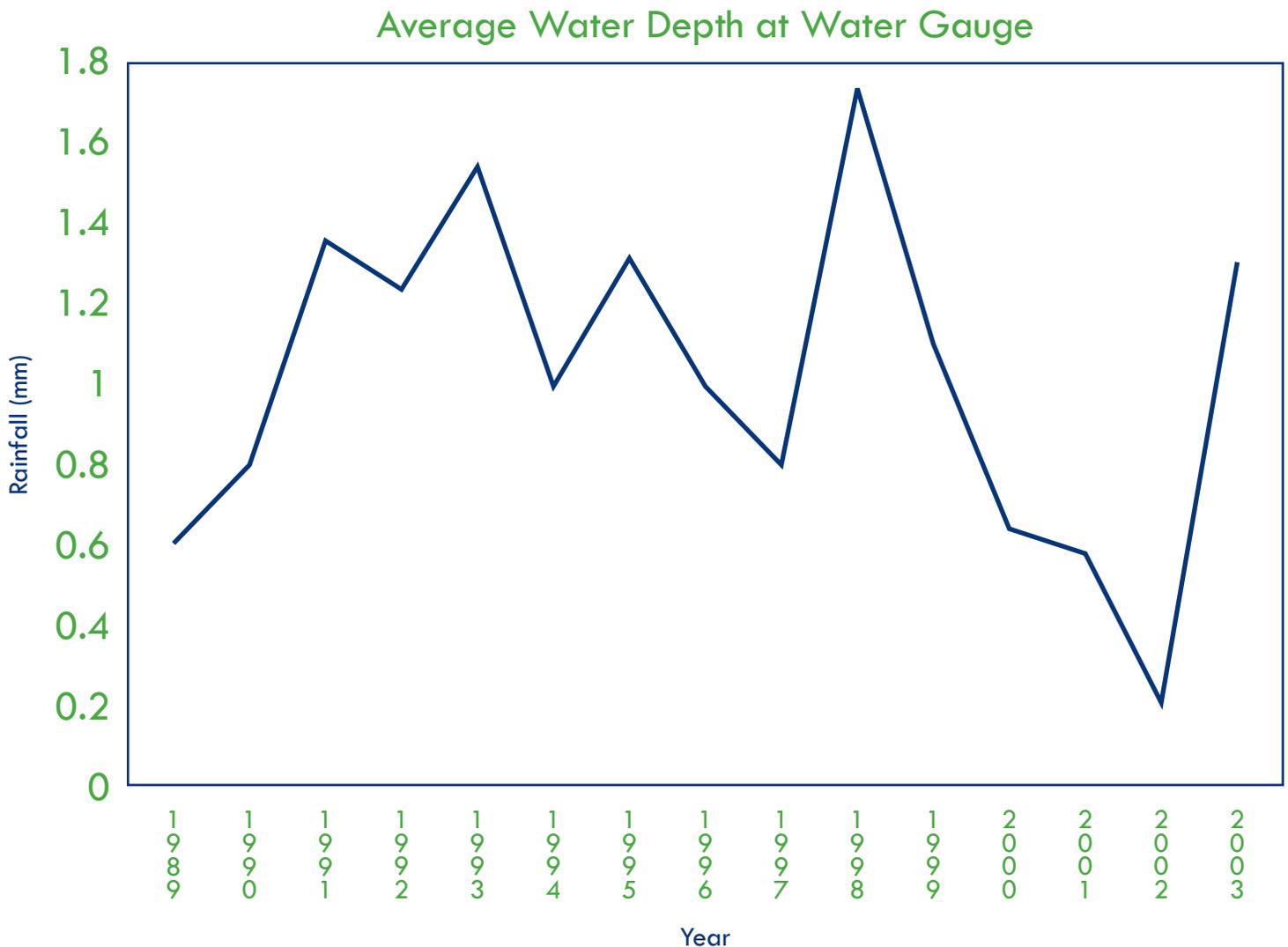


Figure 10. The graph shows the average maximum water depth at the water gauge of seven Carolina bays from 1989 to 2003. Compare this graph with figure 9.

## Reflection section

- How is the pattern of a person's development similar to or different from a Carolina bay?
- How do you think aquatic plants return to the bay after a drought period?

wetlands around the world might change over long periods of time.

Over the next 30 to 60 years, it is predicted that the world will experience climate change, likely changing annual rainfall.

Climate change may decrease or increase rainfall. Although scientists do not know what will happen in the future, climate change could affect wetlands around the world. This study helps scientists understand what might happen to Carolina bays and wetlands like them as climate change occurs.

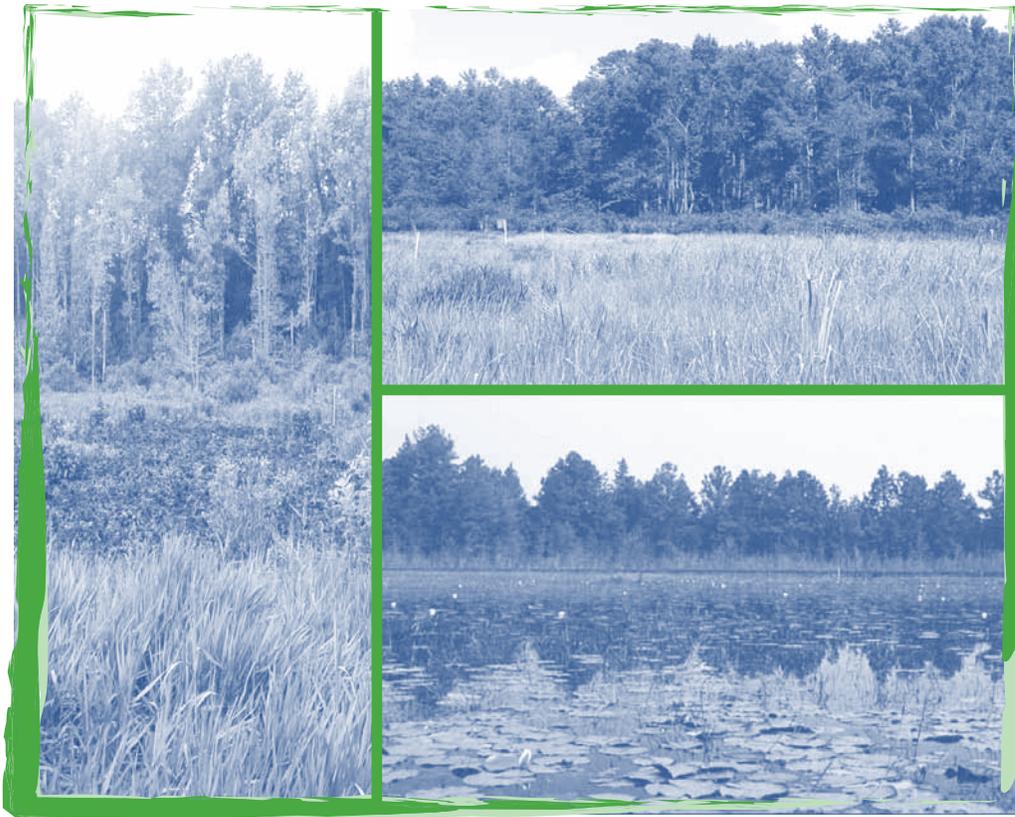


Figure 11. This image shows the bay in different phases. The photo to the left shows the bay in the driest period. The top right photo shows the bay in the between phase. The bottom right shows the bay in the wettest phase.

## Reflection section

- How could climate change affect wetlands?
- What would happen if all the Carolina bays dried up completely? How do you think this would affect the surrounding ecosystem? Think about plants, animals, and humans.

## Discussion

The scientists gained a better understanding of Carolina bays' vegetation patterns. Carolina bays' vegetation patterns show a cyclical model over a long period of time, depending on the amount of rain. These findings will help predict how other freshwater

This article was adapted from Stroh, C.L.; De Steven, D.; and Guntenspergen, G.R. (2008). Effect of climate fluctuations on long-term vegetation dynamics in Carolina bay wetlands. *Wetlands*. 28:17-27. [http://www.srs.fs.usda.gov/pubs/ja/ja\\_stroh001.pdf](http://www.srs.fs.usda.gov/pubs/ja/ja_stroh001.pdf).



# FACTivity

**Time Needed:** One class period; indoor or outdoor.

This FACTivity will represent the methods the scientists used to collect vegetation data in the study. The question students will answer in this FACTivity is: How well does sampling work to represent the entire **population** of something being studied?

**Materials Needed:**

- 200 dried beans (3 different colors: 80 beans represent aquatic plants, 70 beans represent marshy plants, and 50 beans represent woody plants (NOTE: You are starting with 40-percent “aquatic” beans, 35-percent “marshy” beans, and 25-percent “woody” beans. This will be important to remember later on!).
- 8 pieces of string or yarn, each 6’ long with knots or tape every foot.
- Three pieces of thin rope or thick string (one piece 20-25’, one piece 35-40’, and one piece 55-60’), with the ends tied to make three large loops.
- A toilet plunger.
- A large piece of fabric, about 7-8’ square (an old sheet works well).
- 48 paper plates with the center cut out (leaving only about 1” so that the plate becomes a ring).
- Paper and pencil for recording data.
- Chart to record data (see below).

Think about the different types of plants in a Carolina bay wetland. Then think about how the scientists sampled areas in the Carolina bays. You will do something similar in this FACTivity.

Take the large piece of fabric and place it on the ground. This area is the water in the wetland. Remember wetlands are not perfectly round, so students may cut the fabric to make the wetland into a unique (but somewhat round) shape. Have students choose a center point of the wetland and place the toilet plunger at this point.

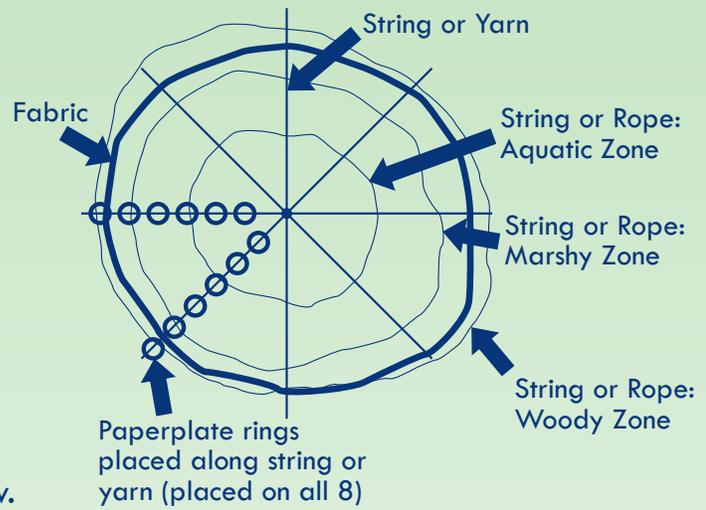
The three pieces of looped string indicate the different vegetation zones. Each looped string will be placed on the “wetland,” around the center. The first zone from the wetland is the aquatic plants (the smallest loop), the second is the marshy plants (the next biggest loop), and the third is the woody plants (the largest loop). The zones should be somewhat concentric around the center pole, and the largest loop may go outside of the “wetland.” Scatter the appropriate color beans in the right zone.

Divide the class into eight groups. Give each group a piece of string. Tell the groups to attach all eight pieces of string to the pole. Stretch out the string away from the pole like eight equal pieces of pie. Tell the students to place the paper plate rings at each knot in the string, with the center of the ring at the knot. (Compare with photo, page 21.) For the area closest to the pole, start at the second knot. Have the students count and record the number and color of the beans in each zone located within the ring. Each group will count the beans within six rings. One student will record the zone and the total number of beans found within all of the rings in each zone.

Repeat this exercise at least three times. To record observations provide each group with a copy of this chart. Remember, not every one of these boxes will be filled out. This should become clear as you do the FACTivity.

Student Names:

	Ring 1	Ring 2	Ring 3	Ring 4	Ring 5	Ring 6	Total Number
Aquatic Zone							
Marshy Zone							
Woody Zone							



Then, add the number of beans in each category from all eight groups and put the numbers in the chart below.

	Aquatic Zone	Marshy Zone	Woody Zone
First Sampling			
Second Sampling			
Third Sampling			
Total Number			

Add the total number of beans that fell under all of the rings for each sampling. (Add the last row of the chart above and record the number below.) Then add across to get the total number.

Aquatic Zone	Marshy Zone	Woody Zone	Total Number

Now calculate the percentage of each color of beans you found in your samples compared to the total number of beans in all of the samples. Write this in the table below. You will do this by dividing the total number found in the rings (from each zone, columns 1 to 3 from the chart above) in each zone by the total number of beans in all of the rings (column 4 from the chart above).

Aquatic Zone	Marshy Zone	Woody Zone

Now, compare the 3 percentages above with the original percentages. (You can find the percentages in the first line under "Materials" at the beginning of this FACTivity). How do the numbers compare? Did your sample percentages resemble the percentages of the population of beans? Why do you think this is so? Answer the question posed at the beginning of this FACTivity. Why do scientists often choose to take a sample of what they study and not identify or study every individual? If you continued to sample three more times, do you think your sample percentages would come closer to the population percentages? Why or why not?



If you are a Project Learning Tree-trained educator, you may use activity #29, "Rain Reasons" and # 71, "Watch on Wetlands" as an additional resource.

**Additional Web Resources:**

USGS's National Wetlands Research Center  
<http://www.nwrc.usgs.gov/>

EPA's Wetlands, Oceans, and Watersheds Kids' Page  
<http://www.epa.gov/owow/kids.html>





Think Outside the Box

Predicting the

spread

of Invasive Species

# Meet the scientists

**Dr. Tom Crist, Terrestrial Ecologist:** My favorite science experience was conducting field studies on the **biodiversity** of forest canopy insects in Ohio.



**Dr. Bob Parmenter, Wildlife Ecologist:** My favorite science experience has been working on the Mount St. Helens volcano since its explosive eruption in 1980. In the early years after the eruption, the roads were destroyed. My crews and I helicoptered into our study sites, where we examined the diversity and **population** sizes of the surviving plant and animal **species**. Over the last three decades, we've returned many times to witness and record the remarkable recovery of the plants and animals. This recovery provides evidence of Nature's **resilience**. I'm looking forward to going back in 2010 for the 30-year reunion of scientists that have worked there since the eruption—along with new generations of science students!

**Dr. Ariel Lugo, Tropical Ecologist:** My favorite science experience is trying to understand the functioning of natural ecosystems in **collaboration** with bright people, including high school students.

## Glossary

**biodiversity** (bi ò duh vür suh tē): A measure of the differences between the types and numbers of living things in a natural area.

**population** (päp yoo la shun): The whole number of individuals of the same type occupying an area.

**species** (spe sez): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure.

**resilience** (re zil yentz): The ability to recover from or adjust easily to change.

**collaboration** (ku la бүр a shun): Working together with others.

**data** (da tuh): Facts or figures studied in order to make a conclusion.

**invasive species** (in va siv spe sez): Native or nonnative species that, by expanding their populations very rapidly, modify the environment and affect the economy or human health.

**nonnative** (nän na tiv): Not naturally occurring in an area.

**economy** (e kôn ò me): A system of interactions and exchanges sometimes involving money.

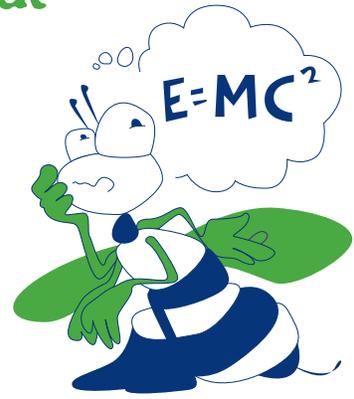
**ecosystem** (e kò sis tem): Community of plant and animal species interacting with one another and with the nonliving environment.

**scale** (skal): Distinct series of levels or measured areas.

**invertebrate** (in vür tuh bret): Lacking a backbone.

**globalization** (glob ul i za shun): Becoming more worldwide in scope.

## Thinking About Science



Sometimes scientists examine existing **data** in a new way to figure out a problem or understand what should be done next. They might also look at the way other scientists have done research in the past to see if trying a new way might provide more useful information. One way scientists do these things is to read, discuss, and observe what has already been done.

In this study, scientists wanted to better understand and predict the spread of **invasive**

**species**. Invasive species are usually **nonnative** species that change the environment, the **economy**, or human health. To make better predictions about where invasive species will spread, the scientists looked at how scientists currently predict the spread of invasive species. After the scientists studied how predictions are currently made, they made suggestions for improving the method. Making

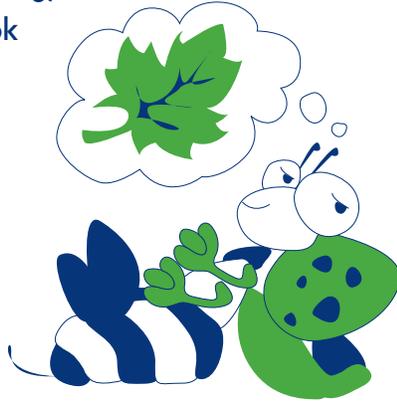
### Pronunciation Guide

<u>a</u>	as in ape
ä	as in car
<u>e</u>	as in me
<u>i</u>	as in ice
<u>o</u>	as in go
ô	as in for
<u>u</u>	as in use
ü	as in fur
<u>oo</u>	as in tool
ng	as in sing

Accented syllables are in bold.

more accurate predictions about the future will help scientists better understand the environment, manage **ecosystems** and the economy, and protect human health. No matter what they are studying, scientists always look for better ways to do their research.

## Thinking About the Environment



The scientists in this study were concerned with the spread of invasive species and their impact on the natural environment. To understand the spread of invasive species, the scientists needed to study the problem at many different levels in the natural environment. In science, we call the different levels **scales**.

Studying invasive species in a local community would be an example of a small scale study. In a small scale study, scientists study the habitat immediately surrounding the plant or animal. Studying invasive species by State, region, or the whole world would be a much larger scale study. As the scale of a study gets larger, less detail is examined. Environmental scientists sometimes focus on the larger scale to examine how large areas containing plants and animals interact with the land. Think of something you have studied in school that could be examined at several different scales.

## What are Ecosystem services?

Ecosystem services result in benefits that people receive from ecosystems. Ecosystem services are often put into four categories. These categories are (1) those that provide, (2) those that regulate, (3) those that support, and (4) those that help people culturally. Ecosystem services that provide, for example, include the products of trees. This is because trees provide food, wood products, and fuel. Ecosystem services that regulate include, for example, processes that help slow the spread of invasive species. Supporting ecosystem services refer to things like the continual cycling of carbon and nitrogen from Earth to the atmosphere and back. This is because these elements support life. Cultural services are provided by places for educational or recreational activities, such as streams for canoeing. For more information on these four categories, read the “Welcome” at the beginning of this journal on page 6 or visit [http://www.fs.fed.us/ecosystemservices/About\\_ES/index.shtml](http://www.fs.fed.us/ecosystemservices/About_ES/index.shtml).

In this research, the scientists wanted to do a better job of predicting the spread of invasive species. When invasive species spread to new areas, the plants and animals that naturally live there are affected and even die. The normal ecosystem services that these native plants and animals provide are then no longer available unless other organisms replace them.

# Introduction

People can now travel to most places because transportation has greatly improved. Countries can easily trade with many different countries across the planet. This process is called **globalization**. Globalization causes many things to happen. For the scientists in this study, globalization has increased the spread of invasive species. With more people, animals, and plants moving back and forth between places, it is easier for invasive species to move from place to place. If scientists can predict the spread of invasive species, the spread may be slowed or stopped. The question the scientists in this study wanted to answer is: How can scientists better predict the spread of invasive species?

## Reflection Section

- Think of one advantage of globalization for you or your community. Think of one disadvantage of globalization for you or your community.
- In your own words, state the problem that the scientists wanted to study.

## Method

The method scientists used to study this problem was interesting and fun. About 100 scientists met in New Mexico at a conference. The scientists met in small groups based on topics of interest. For example, some of the topics included hurricanes, sea level rise, and coastal wetlands. Each group of scientists decided to write papers about

their own topic. Because the scientists lived all over the United States, they had to use technology to communicate with each other. The scientists communicated on the phone, in person, and through emails.

To answer their question, the scientists examined the research that had already been done on invasive species. The scientists examined the methods other scientists used to make predictions about the spread of these invasive species. When a particular example is studied, this is called a case study. An example of a case studied was the zebra mussel.

The zebra mussel invaded the Great Lakes and has moved into rivers surrounding the Great Lakes (**figure 1**). The zebra mussel affects the lakes' ecosystem in many ways (**figure 2**). Zebra mussels change the environment by disrupting food webs and causing native mussels to die. To predict the movement of a plant or animal such as zebra mussels, scientists sometimes create models of what might happen. These models are built on computers, and they represent what might happen in real life. Models are used to make predictions about many different things. When you see a prediction of the path that rain, snow, or a hurricane might take in the future, you are looking at the results of a computer model.

The scientists looked at many predictions and the computer models upon which they were based. Then, they worked together to evaluate which predictions were the most successful.

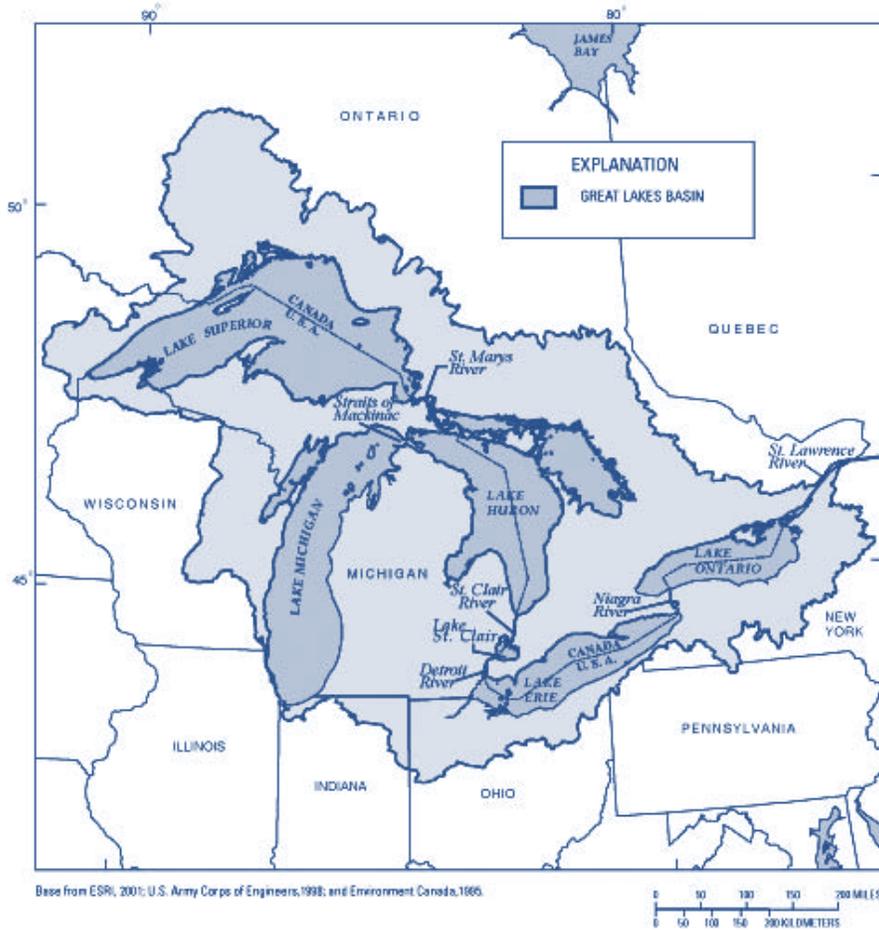


Figure 1. The Great Lakes and the States that surround the Great Lakes. Do you live near the Great Lakes?



Figure 2. The adult zebra mussel can attach itself to a boat. Sometimes the zebra mussel moves into a new area because it has attached itself to a boat. Photo courtesy of USGS, <http://nas.er.usgs.gov/taxgroup/mollusks/images/zebramussel9.jpg>

## Reflection section

- After reading the Method Section, how do you think technology helps scientists to work together?
- Why do you think scientists examined a lot of different case studies before they made a decision about the best way to track the spread of invasive species?

## Findings

Five scientists worked together to develop a paper on invasive species. The scientists had different views on the spread of invasive species. The scientists had to have many discussions to come to an agreement about their different points of view. Each scientist had to think carefully and consider the ideas of the other scientists.

The paper the scientists wrote about predicting the spread of invasive species combines different ideas about invasive species into one story. Once the invasive species paper had been written, the paper was passed back and forth between all the scientists for editing and comments.



After the scientists agreed with what was written, the paper was sent out for peer review. Peer review is a process involving others who are considered an equal in knowledge or skill. In this case, other scientists read the paper and provided comments and suggestions. These other scientists had not been involved with the project before then, but they knew about invasive species. After this review, the paper was published in a journal.

In their paper, the scientists discussed their findings about predicting the spread of invasive species. The scientists found that some models of the spread of invasive species were more successful at prediction than others. They were more successful if they examined larger geographic scales. The scientists recommended that in the future, scientists should examine the spread of invasive species at all geographic scales.

perspectives. Science benefits from lively discussion with different points of view on the same topic. Progress is made in science when different points of view can be combined into one story. The scientists had different ideas but were able to come to an agreement on how the spread of invasive species should be predicted. The efforts of these scientists allowed the study of ecosystem services and invasive species to advance.

The importance of studying invasive species at different geographical scales was highlighted in the scientists' paper. Understanding the impact of invasive species on the local level as well as the impact at a larger geographical scale is important. Examining the possible impact at the larger geographical scale will help scientists make better predictions. The scientists suggested that this larger geographical study needs to be a coordinated effort among scientists across the globe.

### Reflection section

- Think of a time when you benefited from a discussion with someone else. How did it help you?
- Why do you think scientists want to more accurately predict the spread of invasive species?

### Reflection section

- How do you think sharing different opinions on a topic would help scientists better understand invasive species? Use an example from your own life to help you explain.
- Why do you think it is important for scientists to coordinate their efforts?

## Discussion

The scientists who wrote this article on invasive species benefited from examining the issue of invasive species from different

This article was adapted from Crowl, T.A.; Crist, T.O.; Parmenter, R.R.; Belovsky, G.; and Lugo, A.E. (2008). The spread of invasive species and infectious disease as drivers of ecosystem change. *Frontiers in Ecology and Environment*. 6(5): 238-246. Available online at [http://www.fs.fed.us/global/iitf/pubs/ja\\_iitf\\_2008\\_crowl001.pdf](http://www.fs.fed.us/global/iitf/pubs/ja_iitf_2008_crowl001.pdf).

# FACTivity

In this activity, students will explore their schoolyard at different scales. The question students will answer is:

What are the similarities and differences of the schoolyard ecosystem at different scales?

## Materials Needed:

Yarn/string, scissors, clipboard, paper

## Examining Scale in the Schoolyard

### Procedure:

Split students into 10 groups of three students each. These groups will study the schoolyard at different scales. Each group will measure an amount of string and cut it. Two groups will cut a 4 foot length of string or yarn. Two groups will cut an 8 foot length of string or yarn. Two groups will cut a 15 foot length of string or yarn. Two groups will cut a 30 foot length of string or yarn. Tie the ends of each length together, so that each group has a circular piece of string or yarn. You may need to adjust the sizes depending on the amount of outdoor area you have at your school.

Assign each group a notetaker and give them each a clipboard and paper.

Before heading outside, tell the students that they are to examine an area of land in the school yard that fits within the circle their yarn makes. Ask them to brainstorm categories of things they might find in the schoolyard. Examples include insects, plants, animals, nonliving natural things, and nonliving man-made items.

Each group will have 20 minutes to explore their area and make notes.

Once students have had time to gather their information, they will present to the class what they found.

As a class, create a four-column chart to write down what students found at different scales. Discuss the chart once all the columns have been filled in. Some discussion questions might include the following:

1. **What do you notice about the items that were found in the different scales?**
2. **What are some similarities and differences between what people found?**
3. **How do you think this activity represents what scientists did in the article we just read?**



If you are a Project Learning Tree-trained educator, you may use PLT Activity #88, "Life on the Edge" as an additional resource.

## Additional Web Resources:

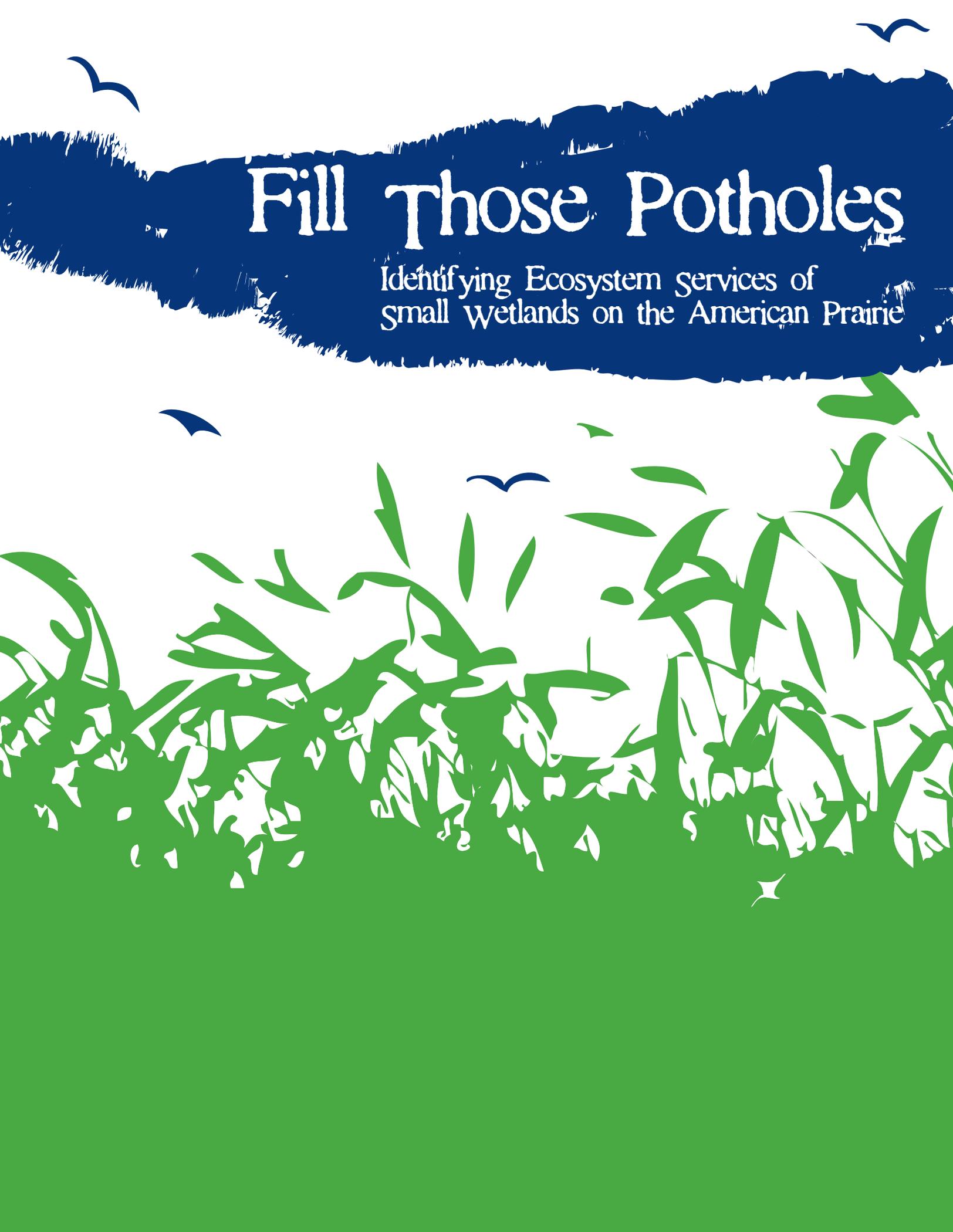
Zebra Mussel Distribution Map: [http://www.nationalatlas.gov/articles/biology/a\\_zm.html](http://www.nationalatlas.gov/articles/biology/a_zm.html)

Forest Service Ecosystem Services Page: <http://www.fs.fed.us/ecosystemservices/usgs.gov/>

USGS Zebra Mussel Information Page:

[http://www.gls.usgs.gov/main.php?content=research\\_invasive\\_zebramussel&title=Invasive%20Invertebrates0&menu=research\\_invasive\\_invertebrates](http://www.gls.usgs.gov/main.php?content=research_invasive_zebramussel&title=Invasive%20Invertebrates0&menu=research_invasive_invertebrates)





# Fill Those Potholes

Identifying Ecosystem services of  
small wetlands on the American Prairie

# Meet the Scientists

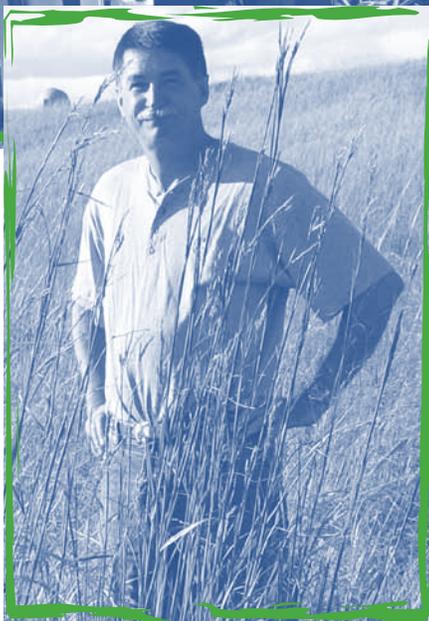
> **Dr. Robert Gleason**, Research Wildlife Biologist: As a wildlife biologist I have had many memorable experiences conducting field work in **wetlands**, including studying soils, plants, **aquatic** insects and other animals, and especially **waterfowl**. The most rewarding aspect of my job, however, is when research results provide the scientific basis for sound **management** and **conservation** of wetland **ecosystems**.



< **Mr. Murray Laubhan**, Ecologist: My favorite science experience is learning something new that helps land managers successfully restore wetlands.



^ **Mr. Brian Tangen**, Biologist: My favorite science experience involved canoeing and back-country camping in the boundary waters wilderness area in northern Minnesota. I did this to conduct research on bald eagle **habitat**.



< **Dr. Chip Euliss**, Research Wildlife Biologist: I am a pretty lucky fellow because I've had many favorite science experiences over my career. Writing this to you is one of my favorites. This is because what I enjoy most about my job is helping teach people about science and how it can improve our lives. The information in this article will teach you about the important services that ecosystems provide to our society.

## Glossary

**wetlands** (**wet** lendz): Areas of land with a lot of soil moisture.

**aquatic** (uh kwat ik): Growing or living in or upon water.

**waterfowl** (wä tür fowl): Birds that spend part or most of their life around or on water.

**management** (**man** ij ment): The conducting or supervising of something.

**conservation** (kän sür **va** shun): The care and protection of natural resources, such as forests and water.

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

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

**agency** (**a** jen se): A separate unit of a government.

**sustain** (suh **stan**): To keep up or maintain.

**natural resources** (**na** cha rôl **re** sôrs es): A supply of something in nature that takes care of a human need, such as oil, forests, or water.

**economic** (**e** kō **nom** ik): Having to do with the management of money in a home, business, or government.

**migratory** (**mi** gruh tôr **e**): Having a characteristic of moving from one place to another.

**breeding habitat** (**bre** ding **hab** uh tat): Environment where an animal nests and reproduces as opposed to where it lives during the rest of the year.

**diversity** (di **vür** suh te): A measure of the differences between the types and numbers of living things in a natural area.

**restore** (**re** stôr): To put or to bring back into a past or original state.

**policy** (**päl** uh **se**): Overall plan with rules that must be followed, generally made by a government.

**variable** (**ver** e uh bul): A thing that can vary in number or amount.

**nutrient** (**noo** tre ent): Any of the substances found in food that are needed for the life and growth of plants and animals.

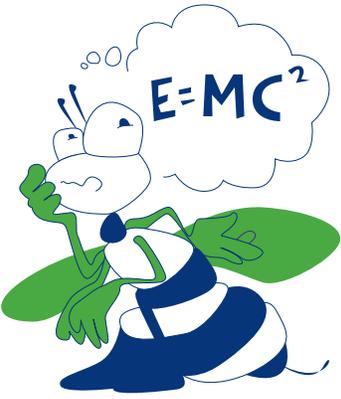
**erosion** (**e** rô zhen) The process or state of wearing or washing away.

## Pronunciation Guide

<b>a</b>	as in ape
ä	as in car
<b>e</b>	as in me
i	as in ice
<b>o</b>	as in go
ô	as in for
<b>u</b>	as in use
ü	as in fur
<b>oo</b>	as in tool
<b>ng</b>	as in sing

Accented syllables are in bold.





# Thinking About Science

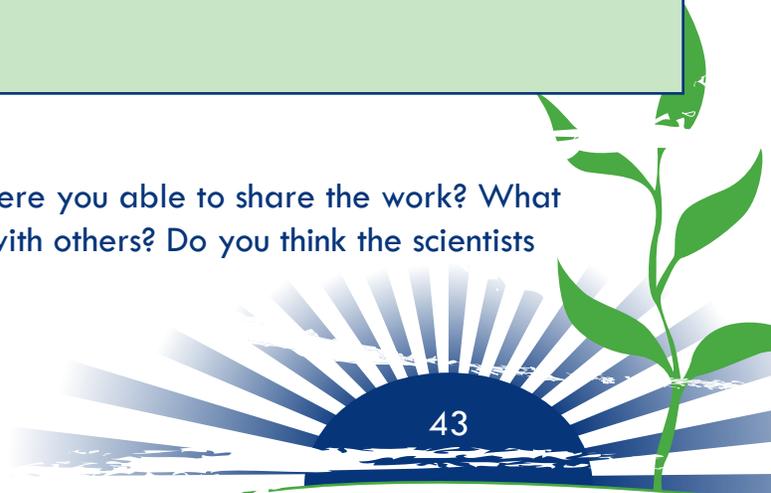
Most scientists, like most people, work as members of an organization. All organizations have a mission. A mission is similar to a goal. Everyone in the organization does their own job to fulfill the mission. Sometimes people in different organizations work with each other. They do this when what they are doing together helps each organization to fulfill its mission.

In this study, the scientists worked for different United States **agencies** (figure 1). These agencies all work to use and **sustain** the Nation's **natural resources**. Even though the agencies all work with natural resources, their missions are different. When scientists work with scientists from other organizations, they can still help their own agencies fulfill their mission. They also save time and money by sharing the work. Whether or not you are a scientist, it makes sense to work with others when you can all achieve your goals by working together. As you read figure 1, compare each agency's mission. How are the missions alike? How are they different?

Agency	Mission
U.S. Department of the Interior, U.S. Geological Survey (USGS)	Serves the Nation by providing scientific information to: <ol style="list-style-type: none"> <li>1. Describe and understand Earth</li> <li>2. Minimize loss of life and property from natural disasters</li> <li>3. Manage water, biological, energy, and mineral resources</li> <li>4. Enhance and protect the quality of life</li> </ol>
U.S. Department of Agriculture, Farm Services Agency (FSA)	Handles farm, conservation, disaster, and loan programs to help farmers manage their land for <b>economic</b> health now and in the future.
U.S. Department of the Interior, U.S. Fish and Wildlife Service (FWS)	Works with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.
U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS)	Helps people help the land through conservation programs.

Figure 1. The U. S. agencies involved in this research.

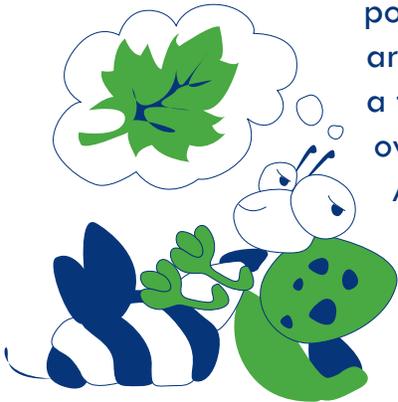
Think of a time when you worked with others. Were you able to share the work? What qualities does a person need to work successfully with others? Do you think the scientists in this study had these qualities? Why or why not?



# Thinking About the Environment

The Prairie Pothole Region of North America is an area of the northern Great Plains (**figure 2**). This area was once mostly made up of mixed grass and tallgrass prairies (**figures 3 and 4**). When the glaciers receded 10,000 years ago in this area, they left millions of shallow depressions. These depressions filled with water and are now known as prairie potholes. These potholes

are wetlands which provide a temporary home to over 50 percent of North America's **migratory** waterfowl. Most of the water found in prairie potholes comes from melting winter snow.



In this area of the United States, the soil is good for growing agricultural crops. In the past, farmers drained the potholes to increase the amount of land available to grow crops. Over half of the prairie potholes have been drained. This was not good for the waterfowl who depend on the potholes for **breeding habitat**, food, and shelter. Government programs now help farmers and landowners restore the prairie potholes to their wetland condition. As wetlands, the potholes do more than provide habitat for waterfowl. In this research, you will learn about other services provided to humans by prairie potholes. These services are known as ecosystem services.



Figure 2. The Prairie Pothole Region of North America. Notice how this region goes into Canada.



Figure 3. A mixed grass prairie.



Figure 4. A tallgrass prairie.

# Introduction

Ecosystem services are environmental benefits provided by natural areas. Ecosystem services are important to humans. Ecosystem services include things such as providing clean water, clean air, habitat for animals, a variety of plants, and healthy soil. It is believed that prairie potholes provide many important ecosystem services.

Prairie potholes are small wetlands formed when melting snow runs into small depressions in the land (**figures 5 and 6**). In the past, many of these potholes were drained by farmers. The potholes were drained to increase the amount of land available to grow crops. The benefits of having more crops were thought to be more important than the benefits of having prairie potholes.

In 1985, the United States Department of Agriculture (USDA) started two nationwide programs to restore some types of land to their natural state. These programs help landowners and farmers in the Prairie Pothole Region restore the prairie potholes that were drained. The goal of these programs is to restore the ecosystem services that were lost when the potholes were drained.



Figure 5. Prairie pothole.



Figure 6. Prairie pothole.

## Number Crunches

How many years have the two government programs been in operation?

## The Two Government Programs

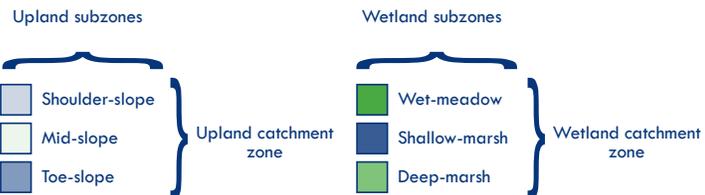
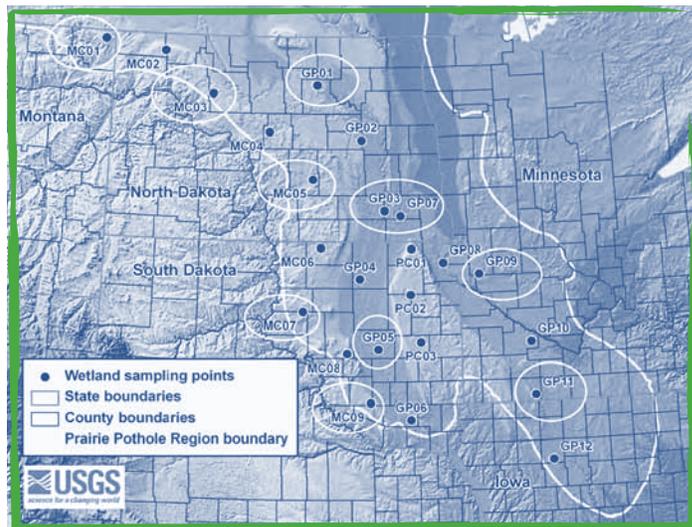
The Conservation Reserve Program (CRP) and the Wetlands Reserve Program (WRP) were established in the 1985 Farm Bill. The Farm Bill is the primary way that agricultural policies are determined by the Federal Government. The CRP encourages landowners to take cropland that is in environmentally sensitive acres and plant grasses or trees instead of crops. The WRP encourages landowners to restore wetlands in areas that had been drained and planted in crops. Landowners receive an annual rental payment for 10 to 15 years. This payment makes up for the money they would have made from selling crops grown on that land. These programs are run by the Natural Resources Conservation Service, or NRCS. (See figure 1 to learn about NRCS's mission.)

Now that the programs have been in operation for many years, it was time to find out whether the programs are achieving their goal. The scientists in this study wanted to know whether some of the ecosystem services provided by prairie potholes are restored when the potholes are restored. They wanted to know how much benefit the restored prairie potholes provide to people, compared to the natural prairie potholes that had never been drained for crops. They also compared the restored potholes with nearby crop land.

## Method

The scientists wanted to know about prairie potholes that had been restored. To restore prairie potholes, farmers and landowners removed unnatural drains and planted grasses and other plants in and around the potholes. The scientists studied 204 potholes in 1997 and 270 pothole areas in 2004 (**figure 7**). The pothole areas included more than the pothole or wetland itself. The areas included the land around the pothole, which drained water into the pothole (**figures 8 and 9**). The restored potholes were surrounded by crop land (**figure 10**).

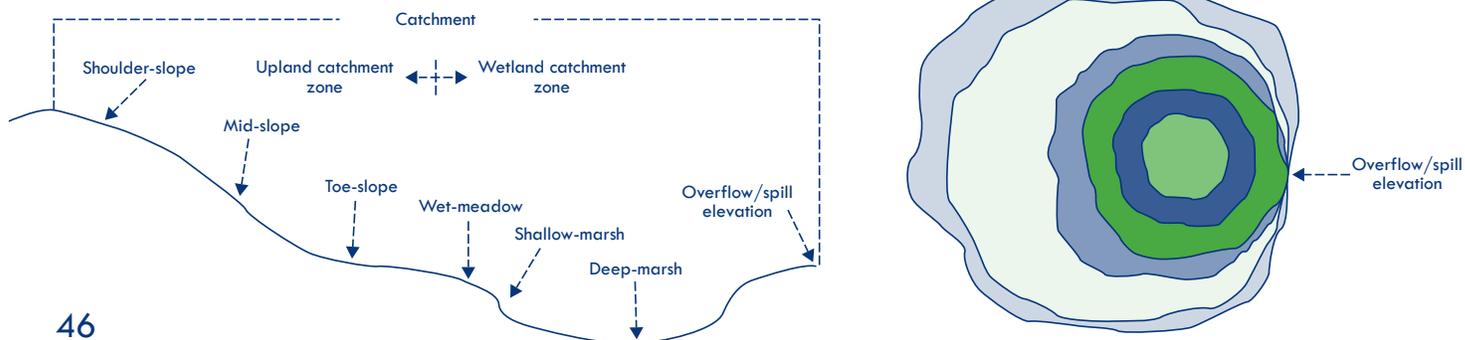
Figure 7. Areas studied in 1997 and 2004. The dots show the pothole areas that were studied.



## Reflection section

- The United States Congress created two programs to help restore land to its natural state. By creating these programs, Congress recognized that some ecosystem services are at least as important as the services provided by agricultural crops or other uses of land. Review the list of ecosystem services in the first paragraph of the “Introduction.” You may also review “Thinking About the Environment” to learn about an important ecosystem service provided by prairie potholes. Do you agree that some of these services are as important as agricultural crops? Why or why not?
- What are the questions the scientists wanted to answer?

Figure 8. Profile of a prairie pothole area.



The catchment area is the land area where water from rain or snow runs downhill into a body of water. The catchment area surrounds the prairie pothole. Compare this photo to figure 8.

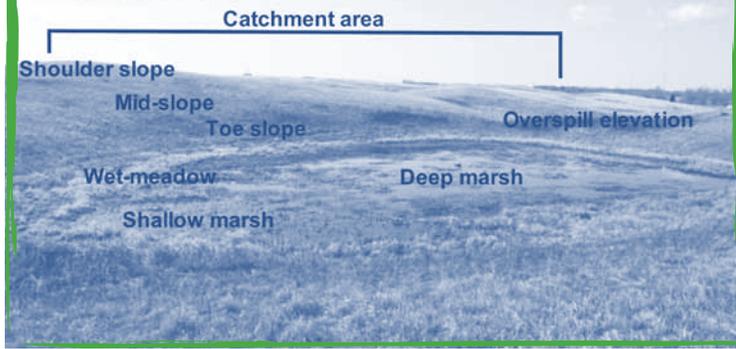


Figure 9. The profile of a prairie pothole using a photograph. Compare this to figure 8.



Figure 10. This restored prairie pothole is surrounded by crop land. Compare this prairie pothole with those in figures 5 & 6.

Variable	Measurement
Soils	Nutrients (Carbon, Nitrogen, Phosphorus)
	pH (A measure of how acidic or basic the soil is)
	Type of soils in the area
Plants (vegetation)	Soil texture
	Types and number of plants in the area
	How much of the ground is covered by plants
	The depth of the dead plant material on the ground
	How much living and once-living plant material is found in the area
Three-dimensional shape	How thick the plants are from the ground to 2 meters high
	How wide each of the zones are (see figure 8)
	The size of the area in hectares
	The physical shape and unevenness of the area
	The volume of water in the pothole wetland

Figure 11. Some of the **variables** measured at each restored and natural prairie pothole or prairie pothole area. The scientists also measured some of these variables on nearby crop land.

When a restored pothole or a restored pothole area was identified, the scientists located the closest natural pothole to it. For each restored and nearby natural pothole area, scientists collected information about its soil, plants, and three-dimensional shape (**figure 11**). They also collected the most of the same information from nearby crop land.

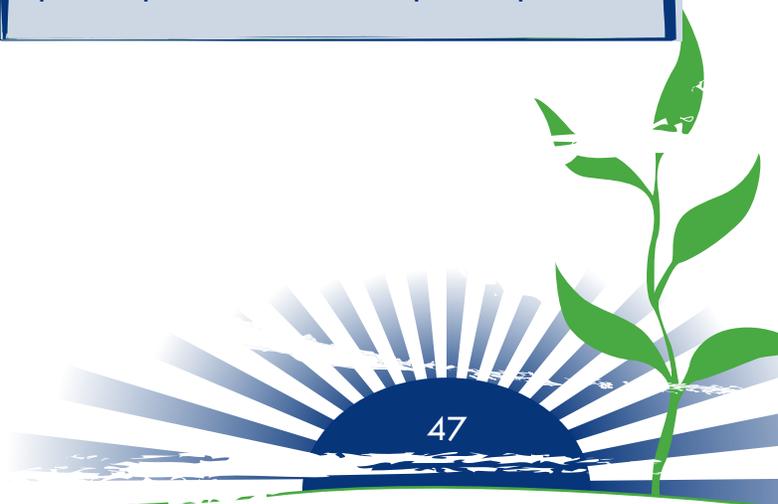
The scientists then compared the information they collected at restored and natural potholes and pothole areas. They also compared this information with information collected at nearby crop land.

## Number Crunches

How many yards high is 2 meters? Multiply 1.09 by 2 to find out. How many feet high is 2 meters? (Note: This measure told the scientists how much protection from plants was available for wildlife around the prairie pothole.)

## Reflection section

- Look at figures 7, 8, and 9. In 1997, the scientists collected information about potholes only. In 2004, they collected information about potholes and the land surrounding the pothole. Why do you think they expanded the study area around each pothole?
- Why did the scientists compare restored prairie potholes to natural prairie potholes?



# Findings

The scientists reported on four ecosystem services. These services were (1) Providing a variety of plant **species**; (2) Helping to address climate change by holding carbon in the soil; (3) Holding rain and storm water in the potholes, thereby reducing the threat of flooding; and (4) Reducing soil **erosion**.

The scientists discovered that the variety of plants in restored potholes and pothole areas was not as great as the variety of plants in natural potholes and pothole areas. They found, however, that the variety of plants in restored potholes was greater than in nearby areas with crops.

The scientists were interested in how much carbon was being held in the soil of prairie potholes and pothole areas. When the soil holds carbon in the form of dead and decaying plant and animal matter, it prevents more carbon from going into the atmosphere. Carbon in the atmosphere contributes to global climate change. When soil holds carbon, therefore, it is considered an ecosystem service.

The scientists found that natural prairie potholes and pothole areas hold more carbon than either restored potholes or areas with crops. The scientists expected the soil of restored potholes to contain more carbon than areas with crops, but they did not find this to be the case.

The scientists were also interested in how well the potholes could prevent flooding in nearby areas. They estimated that all of the restored and natural prairie potholes in the United States could hold an amount of water equal to 56,500 hectares 1 meter deep. This equals 458,000 acres of water 1 foot deep (**figure 12**). The scientists concluded that prairie potholes provide a service to people because they can help protect people from floods.

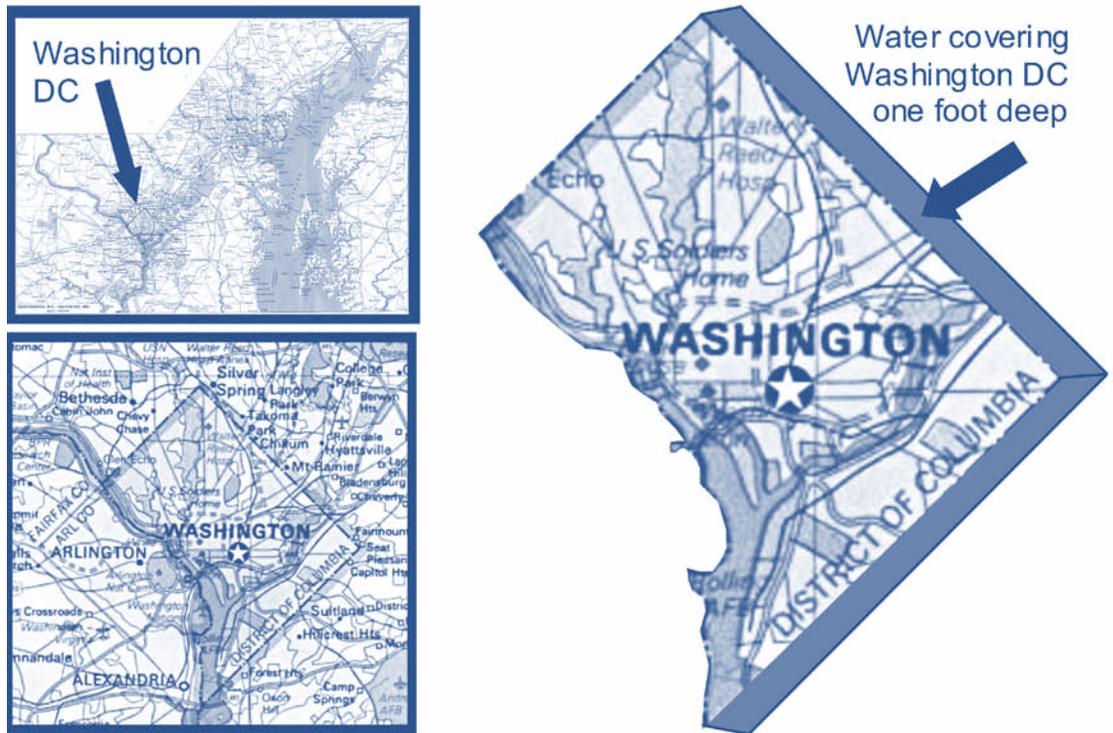


Figure 12. An area of water covering 458,000 acres and 1 foot deep. This is a little less than the area of the District of Columbia.

The scientists also discovered that soil erosion was reduced in the restored prairie potholes as compared to land with crops. One of the greatest benefits of reduced soil erosion is that the pothole wetlands do not fill with soil. They can, therefore, remain pothole wetlands and continue to provide all of the services listed above (figure 13).

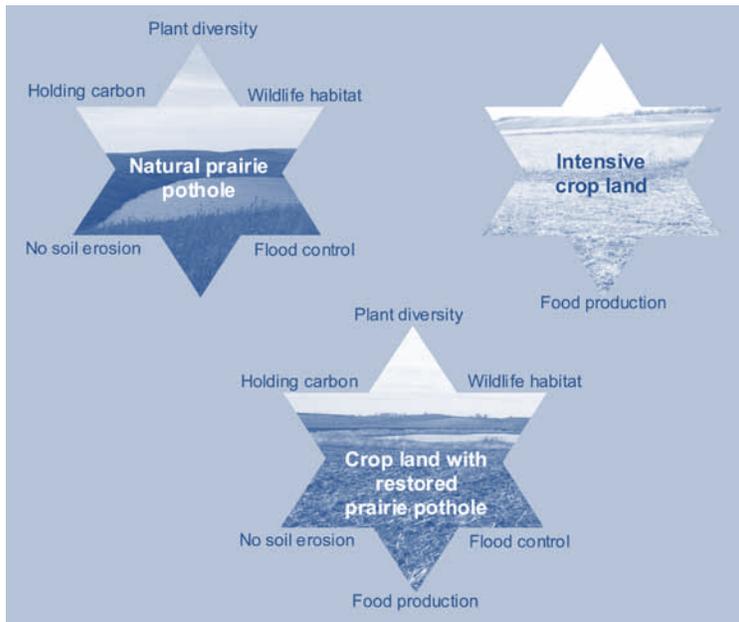


Figure 13. A comparison of the ecosystem services provided by natural prairie potholes, intensive crop land, and crop land with restored prairie potholes. Adapted from [rs.resalliance.org/wp-content/tradeOff.jpg](http://rs.resalliance.org/wp-content/tradeOff.jpg).

## Discussion

The scientists believe that much more research has to happen before they can identify and measure all of the ecosystem services provided by prairie potholes. They also believe that the CRP and the WRP have helped to provide ecosystem services to people. The programs have done this by encouraging farmers and landowners to restore some of their cropland back to prairie potholes and pothole areas.

### Reflection section

- Based on the findings of this research, what is another research question the scientists could ask about prairie potholes and prairie pothole areas? (Hint: Reread the findings having to do with carbon and climate change.)
- Do you agree that the CRP and the WRP have helped to provide ecosystem services? Why or why not?

### Reflection section

- Based on the findings reported by the scientists, do you think prairie potholes provide valuable ecosystem services to people? Why or why not?
- The scientists reported on four ecosystem services. Based on your reading of this article, what is one other ecosystem service provided by prairie potholes and pothole areas?

Adapted from: Gleason, R.A.; Laubhan, M.K.; and Euliss, N.H. Jr.; eds., 2008. *Ecosystem services derived from wetland conservation practices in the United States Prairie Pothole Region with an emphasis on the U.S. Department of Agriculture Conservation Research and Wetlands Reserve Programs*. U.S. Geological Professional Paper 1745, 58 p. <http://pubs.usgs.gov/pp/1745/pdf/pp1745web.pdf>.



# FACTivity

**Time Needed:** One class period

**Materials Needed:**

Visit <http://www.naturalinquirer.org> and print one each of the following articles:

Urban Forest Edition: (1) What you see is not what you get, (2) I've got you covered, (3) Good to the last drip, (4) Yard sale!, (5) Social groupies, (6) Balancing act.

Wilderness Benefits Edition: (1) Wilderness makes sense, (2) Elemental, my dear! (3) Can you hear me now? (4) Speakological, (5) As the frog hops.

Students will divide into pairs.

(These 11 articles should be enough for each pair of students to have their own article. If all of these articles cannot be printed, select enough so that the class is in groups of three to four and each group has its own article. More than one pair of students can read the same article.)

Each pair (or group) should have a blank piece of lined paper and a pencil.

The question you will answer in this FACTivity is: What are other ecosystem services provided by the Nation's natural resources? The method you will use to answer the question is:

**5 minutes:**

As a class, discuss the term "ecosystem services" and what it means. If you have not done so before, read "Welcome to the Ecosystem Services Edition of the *Natural Inquirer*" on page 6. Before continuing, students should understand what ecosystem services are in a broad sense. In other words, students should understand that all natural areas provide at least one ecosystem service, or environmental benefit, to humans. Some of them provide many ecosystem services.

**15 minutes:**

Each pair (or group) of students will have an article and a blank piece of lined paper and a pencil. The pair (or group) should write their names and the article title on the top of the paper. Each pair will read only the following article sections: Thinking About the Environment, Introduction, Method, Findings, Discussion. Students should read the article aloud, rotating paragraph by paragraph.

**10 minutes:**

Each group will identify as many ecosystem services as possible found in their article. Note that these services may not be identified as such in the article. Students should use their imagination to identify more than one ecosystem service. One student will write these ecosystem services in a list, using this example format:

1. When fruit bats eat fruit, they later defecate the seeds at a place far away from where they ate the fruit. A new fruit tree may then grow. This is an ecosystem service because fruit bats help to spread the seeds of fruit trees and, therefore, enable new fruit trees to grow in new places.

**10 minutes:**

Students will share their list of ecosystem services with the class. Hold a class discussion about the types of services provided by the natural environment. Do the services identified provide important benefits? Why or why not?

Students should turn in their sheets to the teacher. The sheets can be used for assessment.



If you are a Project Learning Tree-trained educator, you may use #71, "Watch on Wetlands" as an additional resource.

## FACTivity Extension



For homework, students will observe the natural land (and water) around them and identify as many ecosystem services as possible. Students can start with the schoolyard, looking out of the bus or car window, observe while they are walking, or explore the area around their home. The ecosystem services should be identified in written form, using the format given above. In class, using a rapid-fire format, students will share their observations. Students should consider all they have learned about the environment to identify ecosystem services. Students may be assessed on the number of ecosystem services identified, and the clarity and correctness of written expression.

**Additional Web Resources:**

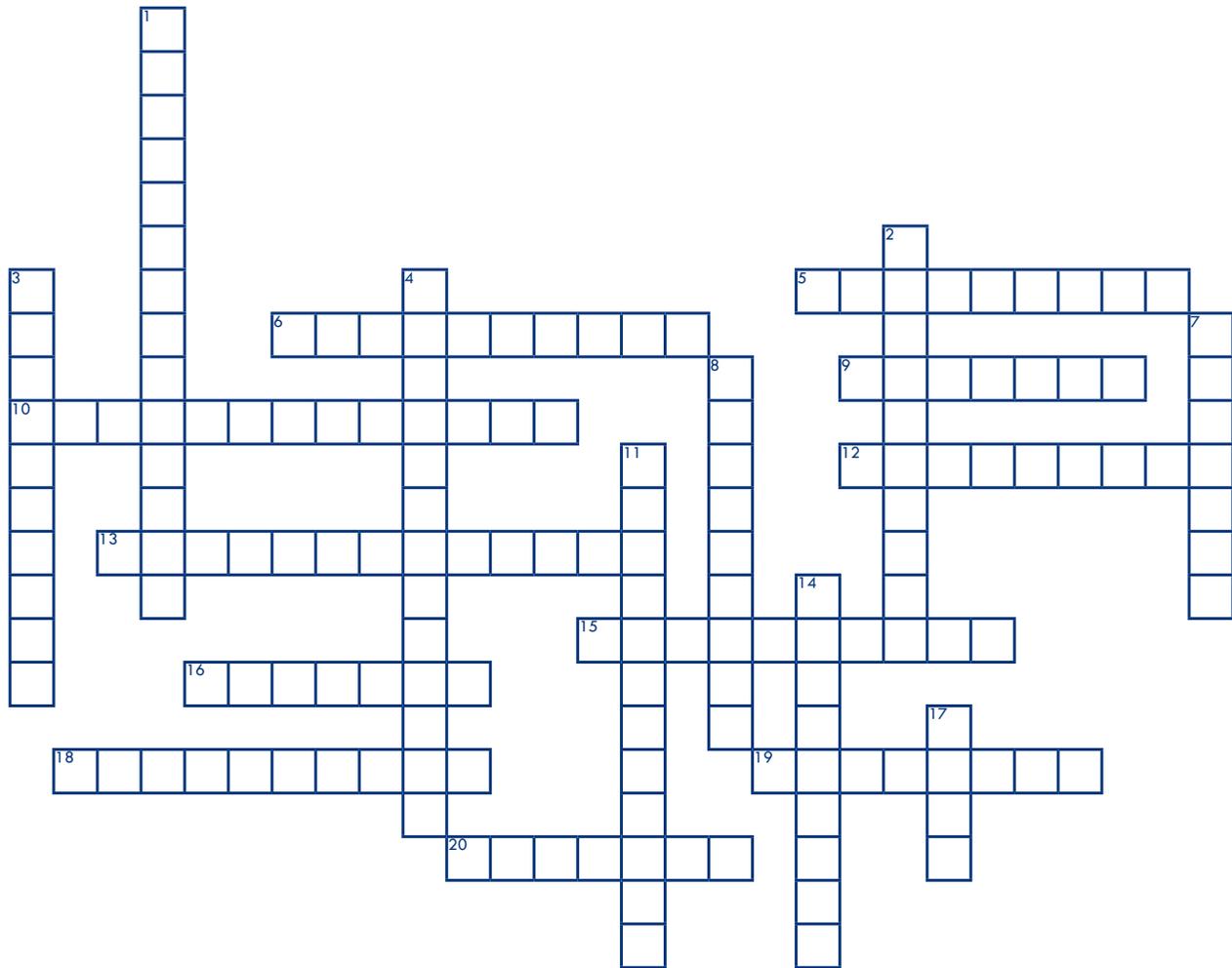
Scientific American podcast on ecosystem services, 60-second Earth:  
<http://www.sciam.com/podcast/episode.cfm?id=why-ecosystem-services-matter-09-02-05>

Ecological Society of America: Ecosystem Services: A Primer:  
<http://www.esa.org/ecoservices/comm/body.com.fact.ecos.html>

Forest Service Ecosystem Services:  
<http://www.fs.fed.us/ecosystems-services/>



# Ecosystem services Crossword Puzzle



## Across

5. Community of plant and animal species interacting with one another and the nonliving environment
6. Plant life
9. To keep up or maintain
10. Plants growing or living upon water
12. A bird that spends part or all of its life around or on water
13. Working together with others
15. The ability to recover from or adjust easily to change
16. The process or state of wearing or washing away
18. Flat land area next to a stream or river
19. Thing that can vary in amount or size
20. Groups of organisms that resemble one another in appearance, behavior, chemical processes and genetic structure

## Down

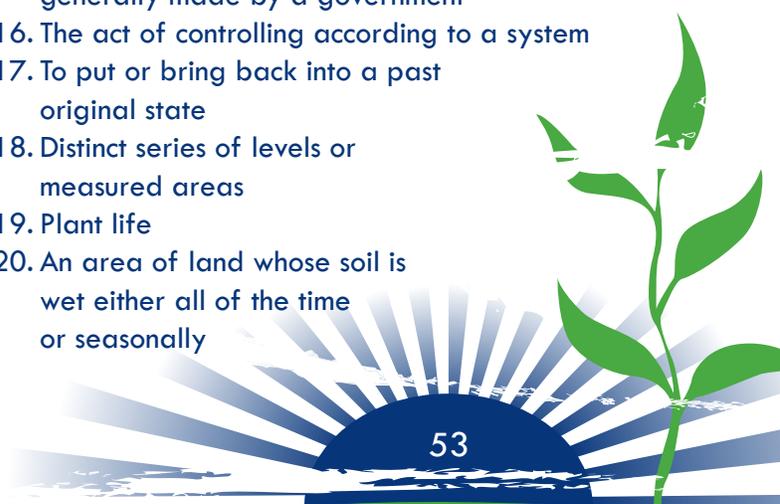
1. A method used by scientists to group or categorize species of organisms
2. The whole number of individuals of the same type occupying an area
3. The conducting or supervising of something
4. The process of change in some animals from an immature stage to an adult stage
7. An area of land whose soil is wet either all the time or seasonally
8. The quality of being different or varied
11. The care and protection of natural resources such as water and forests
14. Moving from one place to the next periodically
17. Facts or figures studied in order to make a conclusion

# Ecosystem services word search



1. A separate unit of government
2. Occurring every year
3. A measure of differences between the types and numbers of living things in a natural area
4. The care and protection of natural resources such as water and forests
5. Occurring in a pattern that typically happens again and again
6. A period of dry weather with little or no rain
7. Having to do with management of money in a home, business, or government
8. Water source that has a low amount of salt concentration
9. Environment where a plant or animal naturally grows or lives
10. The upper streams that contribute water to another source of water such as a river

11. Lacking a backbone
12. A simplified example of a system in science
13. Not naturally occurring in an area
14. Any of the substances found in food that are needed for the life and growth of plants and animals
15. Overall plan with rules that must be followed generally made by a government
16. The act of controlling according to a system
17. To put or bring back into a past original state
18. Distinct series of levels or measured areas
19. Plant life
20. An area of land whose soil is wet either all of the time or seasonally



# Note to Educators

The mission of the Forest Service is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. For more than 100 years, our motto has been caring for the land and serving people. The Forest Service, U.S. Department of Agriculture (USDA), recognizes its responsibility to be engaged in efforts to connect youth to nature and to promote the development of science-based conservation education programs and materials nationwide.

This Ecosystem Services edition of the *Natural Inquirer* combines research done by the Forest Service and the USGS (U.S. Geological Survey). The mission of the USGS is that of serving the Nation by providing reliable scientific information to describe and understand Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.

The *Natural Inquirer* is a science education resource journal to be used with learners from grade 5 and up. The *Natural Inquirer* contains articles describing environmental and natural resource research conducted by Forest Service and USGS scientists and their cooperators. These are scientific journal articles that have been reformatted to meet the needs of middle school students. The articles are easy to understand, are aesthetically pleasing to the eye, contain glossaries, and include hands-on activities. The goal of the *Natural Inquirer* is to stimulate critical reading and thinking about scientific inquiry and investigation while learning about ecology, the natural environment, and natural resources. In this edition of the *Natural Inquirer*, you will find four articles on ecosystems written in the scientific method format.

## The Format of a *Natural Inquirer* Article:

Each *Natural Inquirer* article follows the same format. *Natural Inquirer* articles are written directly from a published science article, and all have been reviewed by the scientists for accuracy. Each article contains



the following sections, which you may introduce to your students as they read:

### Meet the Scientists:

Introduces students to the scientists who did the research. This section may be used in a discussion of careers in science.

### Glossary:

Introduces possibly new scientific or other terms to students. The first occurrence of a glossary word is bold in the text.

### Thinking About Science:

Introduces something new about the scientific process, such as a scientific habit of mind or procedures used in scientific studies.

### Thinking About the Environment:

Introduces the environmental topic being addressed in the research.

### Introduction:

Introduces the problem or question being addressed by the research.

### Method:

Describes the method used by the scientists to collect and analyze their data.

### Findings:

Describes the results of the analysis.

### Discussion:

Discusses the findings and places them into the context of the original problem or question.

### Citation:

Gives the original article citation with a Web link to the original article.

### Science Education Standards and Evaluations:

In the back of the journal, you will find a matrix that enables you to identify articles by the national science education standards that they address. Evaluation

forms for both educators and students are available on our Web site. We welcome any feedback so please visit <http://www.naturalinquirer.org> and complete the online evaluation forms. Additionally, you may contact Dr. Barbara McDonald at the address below with any comments you have.

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)

### **Educator Resources:**

Visit the updated *Natural Inquirer* Web site at <http://www.naturalinquirer.org>. From this site, you can read and download lesson plans, word games, and other resources to help you use the *Natural Inquirer* in your classroom. You can also view and download a yearlong lesson plan aimed at helping your students learn about the scientific process.

Visit the *Natural Inquirer* Web site at <http://www.naturalinquirer.org>.

## Lesson Plan for Ecosystem Services Edition

### **Materials and Supplies:**

- *Natural Inquirer* Ecosystem Services Edition
- Copies of graphic organizer

### **National Science Education Standards Addressed: Content Standards A, C, F**

- A. Abilities Necessary To Do Scientific Thinking
- A. Understanding About Scientific Inquiry
- C. Structure and Function in Living Systems
- C. Regulation and Behavior
- C. Populations and Ecosystems
- G. Science as a Human Endeavor
- G. Nature of Science

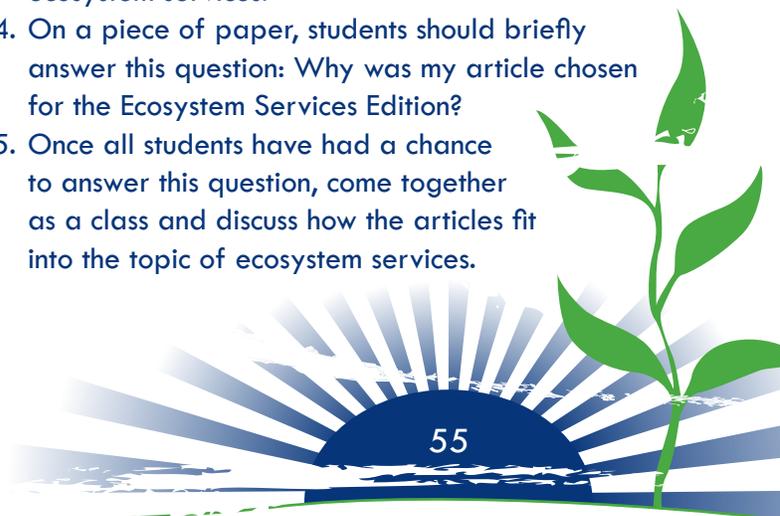
**Time Needed:** Two class periods

### **Class Period 1:**

1. Pass out the Ecosystem Services Edition of the *Natural Inquirer*. As a class, read the “Welcome to the Ecosystem Services Edition” and preview the table of contents.
2. Divide students into four groups and assign each group one article. (If you prefer smaller groups, divide students into eight groups and two groups will be assigned to one article.)
3. Tell students that they are responsible for reading their article and completing the graphic organizer. Each person in the group is responsible for completing the graphic organizer. These graphic organizers will be used to present the article to the class the following class period.
4. Before students begin their assignment also share with them the rubric you will use to grade their work. Make sure students are clear about your expectations before they begin their work.
5. Give students the remainder of the class to read the article and fill out the graphic organizer.

### **Class Period 2:**

1. Ask students to get out their graphic organizers and get into their groups. Allow the students 10 minutes to review what they did yesterday within their groups and prepare to speak to the rest of the class.
2. Once students are prepared, have groups share what they learned from their article.
3. After students have finished sharing about their articles, ask students to go back to their groups and reread the “Welcome to the Ecosystem Services Edition.” While reading this section, ask students to think about how their article fits into the topic of ecosystem services.
4. On a piece of paper, students should briefly answer this question: Why was my article chosen for the Ecosystem Services Edition?
5. Once all students have had a chance to answer this question, come together as a class and discuss how the articles fit into the topic of ecosystem services.



# Natural Inquirer Ecosystem services Graphic Organizer

In one or two sentences summarize the main idea of each section listed below.

*Thinking About Science*

*Thinking About the Environment*

In one or two sentences summarize the main idea of each section listed below.

<i>Introduction</i>	
<i>Method</i>	
<i>Findings</i>	
<i>Discussion</i>	

# Rubric For Ecosystem services Edition

	Unsatisfactory 1	Needs Improvement 2	Satisfactory 3	Exemplary 4	Score
Graphic Organizer	Did not make attempt to fill out graphic organizer	Filled out half of the graphic organizer	Filled out most of the graphic organizer- missed only 1 section	Completed the graphic organizer	
Understanding of Material	Did not demonstrate understanding of material	Limited understanding demonstrated	Demonstrated understanding of material	Added extra evidence to show understanding of material	
Grammar/ Punctuation	More than 8 errors	4-8 errors	1-3 errors	No errors	
Final Question	Did not demonstrate understanding of material	Limited understanding demonstrated	Demonstrated understanding of material	Added extra evidence to show understanding of material	
Score					

## Optional Internet Lesson Plan

### Materials:

1. *Natural Inquirer* Ecosystem Services Edition
2. Access to the Internet

### Time needed: One class period

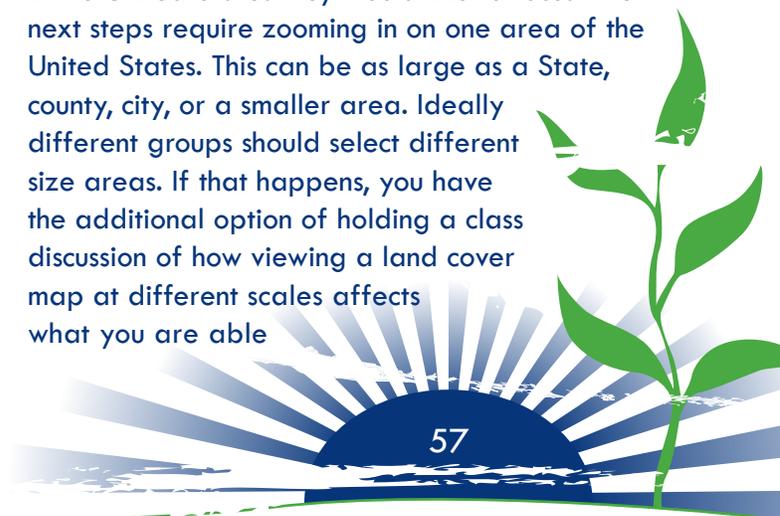
The purpose of this activity is to encourage students to critically think about how land cover, such as trees, water, pavement, and grasses, provides ecosystem services. The students will use an interactive map from the Internet to identify land cover and its associated ecosystem services anywhere in the United States.

This activity works best if students are already familiar with ecosystem services. Review “Welcome to the Ecosystem Services Edition” and at least one of the following articles in the Ecosystem Services Edition: “Fill those potholes!” or “What goes around comes around.” Discuss the idea of ecosystem services with your students.

1. Have students form groups of three or four students each. Each group should have access to the Internet.

Go to <http://www.nationalatlas.gov> and click MAP MAKER. (Note: If you have only one computer available, do this exercise with the entire class.)

2. The screen should show a map of the United States. Students will access different features located on the right of the screen. First, add CITIES AND TOWNS and COUNTIES by clicking in the boxes by each. STATES should already be selected. Then click “redraw the map.” This tab is located on the top of the features box. After any item has been selected or deselected you must redraw the map to view the changes. Students should decide where in the United States they would like to focus. The next steps require zooming in on one area of the United States. This can be as large as a State, county, city, or a smaller area. Ideally different groups should select different size areas. If that happens, you have the additional option of holding a class discussion of how viewing a land cover map at different scales affects what you are able





to understand about land cover and ecosystem services.

3. Once students have chosen an area, it is best if they deselect (or unclick the boxes) CITIES AND TOWNS and COUNTIES. They can then redraw the map, and city, town, and county names will disappear. Now click “Basic maps” to close this option. Click the BIOLOGY feature. Below invasive species, find and click the box beside LAND COVER RESOLUTION 200 and redraw the map. The map should now show different colors that represent different land cover types in the area they have chosen to study. Click on BIOLOGY to close this option.
4. Have students click on WATER. Then click in the box beside STREAMS AND WATERBODIES. Close the water option. Students should again redraw their maps. Their screen will show a map of their area with all land cover categories color-coded, with streams and other water bodies visible.
5. Explain to students that land cover is the physical material at the surface of Earth. Land covers include grass, asphalt, trees, bare ground, water, etc. Each type of land cover has associated ecosystem services. Tell students that they will next think about what kind of ecosystem services are provided by the land cover and water within their map area.
6. Students need to be able to view the land cover key. To view the land cover key, click “map key” at the bottom of the map or in the top right tab. The land cover types and colors should be visible on the right.
7. Now the students are ready to explore the ecosystem services provided by the land cover types on their maps. Students may want to zoom

in closer by clicking on the location on the map. Students can zoom out by clicking the area on the top of the map that says “zoom out.”

8. Have students identify the different land covers and waters in their map area by using the map key and the ecosystem services key provided on page 59. Students should explore by discussing what kind of land cover (and water) is found on their map. Using the Ecosystem Services Key below, students should begin to list the possible ecosystem services provided by the area on their map. Students may have additional ideas about the ecosystem services provided by the area. Each person in the group should write a paragraph about the ecosystem services provided by the land cover on their map. Each student should select at least three ecosystem services about which to write. You may use the rubric located at the end of the lesson plan to assess each student’s progress with the activity.

As an option, once students have “drawn” their maps on the screen, they may print them by clicking “Print map” at the top. They should enter a map title and follow instructions to print.



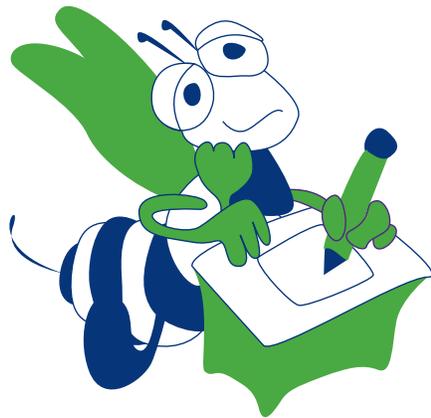
# Ecosystem services Key

- 1. Water:** Water provides aquatic species habitat, food, and shelter. Water also provides drinking water for humans and animals and water for plants. People may use the waterways as a way to get from one place to another.
- 2. Perennial ice and snow:** Provides fresh water for plants and animals.
- 3. Low-intensity residential:** Provides edge habitat for birds, small mammals, and insects. Open areas maybe used by predators to find prey.
- 4. High-intensity residential:** Some insects and a few songbirds or other birds may be found in the area. Some small mammals may find shelter in houses or in other buildings.
- 5. Commercial/industrial/transportation:** A few birds may nest in the buildings or bridges.
- 6. Bare rock/sand/clay:** Different minerals come from each material. Some plants and animals only live on, under, or around rocks. Bare rock provides a place for reptiles to bask in the sun.
- 7. Quarries/strip mines/gravel pits:** Large pools of water can form in quarries after a rain and provide temporary water for animals.
- 8. Transitional:** This area provides food and shelter for many different types of animals.
- 9. Deciduous forest:** Provides food, shelter, and habitat for a wide variety of animals. Wood can be harvested to make homes and other products. Leaves fall to the ground and provide nutrients to the soil. Soil erosion is reduced in deciduous forests. Trees also take in and hold carbon, which reduces the amount of carbon dioxide in the atmosphere.
- 10. Evergreen forest:** Provides food, shelter, and habitat for animals. Cover is available to animals all year long. Wood can be harvested to make homes and other products. Trees also take in and hold carbon, which reduces the amount of carbon dioxide in the atmosphere.
- 11. Mixed forest:** Provides food, shelter, and habitat for animals. Some cover is available to animals all year long. Wood can be harvested to make homes and other products. Leaves fall to the ground and provide nutrients to the soil.
- 12. Shrubland:** Food, shelter, and habitat for animals. Soil erosion is reduced because plants hold the soil together.
- 13. Orchards and vineyards:** Insects and birds use the edge for shelter and look for food. Shelter is available for small mammals.
- 14. Grasslands/herbaceous:** Grazing habitat for different animals. Habitat for insects and small mammals. The plants reduce soil erosion.
- 15. Pasture/hay:** Grazing habitat for different animals. Habitat for insects and small mammals. The plants reduce soil erosion. People can use the hay for livestock and can sell the hay for money.
- 16. Row crops:** Insect and songbird habitat. A source of food for people. Some wild animals will also eat the crops.
- 17. Small grains:** Songbird, small mammals, and people food sources.
- 18. Fallow:** Habitat and food source for insects, songbirds, and mammals.
- 19. Urban/recreational grasses:** Insect and songbird habitat. Some small mammals may use this area for habitat.
- 20. Woody wetlands:** Great habitat for many different animals—ducks, amphibians, reptiles, and mammals. Many animals will use this area to raise their babies. Source of water for animals. Wetlands filter the water to keep it clean and to reduce flooding in the areas.
- 21. Emergent herbaceous wetlands:** Great habitat for many different animals—ducks, amphibians, reptiles, and mammals. Many mammals will eat the plants that grow in this area.



	Unsatisfactory 1	Needs Improvement 2	Satisfactory 3	Exemplary 4	Score
Map Maker	Did not make attempt to follow map directions	Filled out half of the map directions	Filled out most of the map directions- missed only 1 section	Completed the map directions	
Understanding of Material	Did not demonstrate understanding of material	Limited understanding demonstrated	Demonstrated understanding of material	Added extra evidence to show understanding of material	
Grammar/ Punctuation	More than 8 errors	4-8 errors	1-3 errors	No errors	
Final Question	Did not demonstrate understanding of material	Limited understanding demonstrated	Demonstrated understanding of material	Added extra evidence to show understanding of material	
Score					

Alternative: Students who have access to the Internet at home may be assigned this for homework. Go through the steps in class prior to making the assignment so students know what to do. You may want to make copies of the numbered instructions and the ecosystem services key for their reference. If you take this alternative, have students print their maps at home. Hold a class discussion the following day and have students share their maps and their paragraphs.



## Reflection Section Answer Guide

### Toad-ally Awesome!

#### Introduction

What was the question the scientists wanted to answer? *How does flooding affect the reproduction of toads in the forests along the Rio Grande?*

How do you think flooding affects the reproduction of toads? *This is an individual question and students should back up their opinions with logic, evidence, and reason.*

#### Method

Why did the scientists also measure the amount of rainfall and the amount of water flow at each of the sites? *The scientists needed to measure these things because the amount of rainfall and the amount of water flow help the scientists determine whether the area flooded or not.*

Why do you think the scientists conducted their experiment from June through September of each year? *This is an individual question. Possible answers*



would be because it is reproduction season, rain season, and snow melt.

### Findings

Look at figure 6. Do you think flooding affected the reproduction of toads? Why or why not? *It appears that flooding does affect the toad population because the scientists captured many more toads where there was flooding.*

What other living things do you think might be affected by flooding? Why? *This is an individual question. Possible answers include other amphibians and their reproduction cycles, insects, plants, and predator/prey relationships.*

### Discussion

Do you think it would be a good idea to purposely flood the bosque periodically? Why or why not? *Yes, because small floods could be safely managed to protect both the people and the toad populations.*

Would people benefit from flooding that would enable the toads to reproduce? Why or why not? *This is an individual question and students should back up their opinions with logic, evidence, and reason.*

## What Goes Around Comes Around

### Introduction

What would happen to the Carolina bays if the directional model were correct? What would happen if the cyclical model were correct? *According to the directional model, the aquatic ecosystem might change into a marsh and then into a swamp (a forested wetland) because of prolonged drought that alters the vegetation to resemble more of a forested wetland than an aquatic wetland. According to the cyclical model, the bays always return to their aquatic ecosystem.*

What question did the scientists ask? *After a period of prolonged drought, do Carolina bays become more forested or do they always return to their aquatic ecosystem?*

### Method

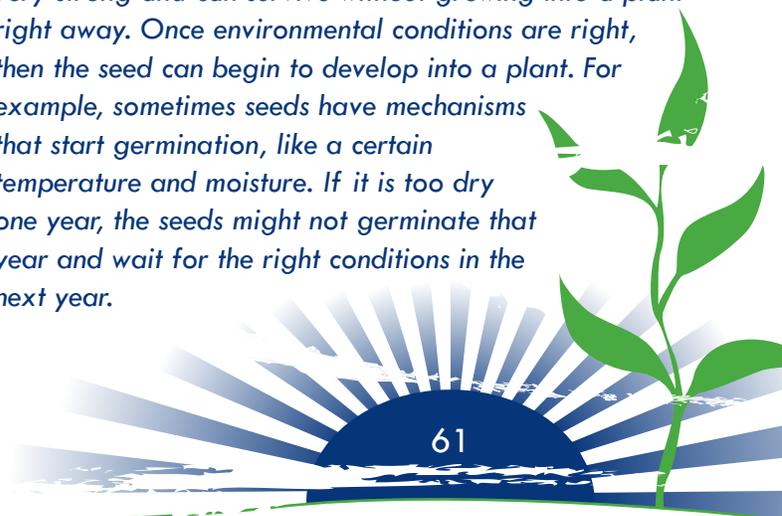
How do you think changes in rainfall affected the aquatic plants, marsh plants, and woody plants around the wetland? *Students may have different answers, which are encouraged as long as they can back up their answer with logic and evidence. Depending on which vegetation type the student focuses on, the amount of rainfall influences which plant can survive. If a lot of rain has fallen, then the bay should contain a lot of water that would encourage aquatic plants to grow, etc.*

An ecosystem is a very fragile system. When something disrupts the balance, the ecosystem may take years to recover. Do you think rainfall only affects vegetation in the current year or can rainfall affect how vegetation grows the next year? Explain. *Students may have different answers which are encouraged as long as they can back up their answer with logic and evidence. The scientists found that it can take more than a year for the bays' water levels to recover from a drought period. This means that vegetation patterns also take a while to change. The amount of water available will determine which plants grow in an area.*

### Findings

How is the pattern of a person's development similar to or different from a Carolina bay? *Carolina bays are cyclical and people change in a directional pattern. Carolina bays can change back and forth from dry vegetation patterns, margin vegetation patterns, and aquatic vegetation patterns. People follow a directional model: baby, child, teenager, adult, etc.*

How do you think aquatic plants return to the bay after a drought period? *Plants put out seeds that are very strong and can survive without growing into a plant right away. Once environmental conditions are right, then the seed can begin to develop into a plant. For example, sometimes seeds have mechanisms that start germination, like a certain temperature and moisture. If it is too dry one year, the seeds might not germinate that year and wait for the right conditions in the next year.*



## Discussion

How could climate change affect wetlands? *There are no right or wrong answers to this question. Scientists are still trying to understand this question. If climate change makes more rainfall, then more wetlands and aquatic systems may occur in an area. If less rain falls, then wetlands may become a lot drier and change to swamps or even to forests with upland trees. This would change the wetlands' job in the ecosystem.*

What would happen if all the Carolina bays dried up completely? How do you think this would affect the surrounding ecosystem? *Think about plants, animals, and humans. Refer to the "Thinking about the Environment" section. Wetlands provide a home to many unique plants and animals and perform many important roles to keep the environment healthy. For example, if the bays dried up, animals that feed on the aquatic plants would have to look somewhere else to get the right food sources.*

## Think Outside the Box

### Introduction

Think of one advantage of globalization for you or your community. Think of one disadvantage of globalization for you or your community. *There will be a variety of answers to this question. Encourage students to explain why they think their answer represents an advantage or disadvantage. Some examples of advantages include increased trade and access to a variety of products to buy. Some disadvantages include jobs being moved out of the community to other places and the increase in invasive species.*

In your own words, state the problem that the scientists wanted to study. *The problem scientists wanted to study is how to better predict the spread of invasive species.*

### Method

After reading the Method Section, how do you think technology helps scientists to work together? *Scientists use technology to communicate, such as by the telephone and email. They also use the computer to examine different case studies, including the computer models that were used to make predictions.*

Why do you think scientists examined a lot of different case studies before they made a decision about the best way to track the spread of invasive species? *If the scientists had only used one or two case studies, they would not have much to compare. They needed to compare successful with unsuccessful predictions. For that they needed more than just one or two case studies.*

### Findings

Think of a time when you benefited from a discussion with someone else. How did it help you? *This is an individual question and students will have many different experiences to share. In all cases, students should be able to identify how they benefited from having a discussion with someone else.*

Why do you think scientists want to more accurately predict the spread of invasive species? *Because when invasive species spread, they affect ecosystem services. This means they change the benefits provided to people by ecosystems.*

### Discussion

How do you think sharing different opinions on a topic would help scientists better understand invasive species? *Use an example from your own life to help you explain. Because the scientists had different areas of expertise, their combined thoughts and ideas made for a much more complete understanding of how the spread of invasive species might be better predicted.*

Why do you think it is important for scientists to coordinate their efforts? *It is important for scientists to coordinate their efforts so that they do not waste time duplicating efforts and so that they work most efficiently.*

## Fill Those Potholes!

### Introduction

The United States Congress created two programs to help restore land to its natural state. By creating these programs, Congress recognized that some ecosystem services are at least as important as the services provided by agricultural crops or other uses of land. Review the list of ecosystem services in the first

paragraph of the “Introduction.” You may also review “Thinking About the Environment” to learn about an important ecosystem service provided by prairie potholes. Do you agree that some of these services are as important as agricultural crops? Why or Why not? *This is an individual question and must be answered by each student individually. Students should be able to back up their reasoning with logic. You may use this question in a class discussion of the tradeoffs between agricultural and environmental (or ecosystem) services and benefits.*

What are the questions the scientists wanted to answer? *Do restored prairie potholes provide ecosystem services? If so, how what kind of services and how much benefit do they provide as compared to the natural prairie potholes that had never been drained? How do they compare in these services to nearby areas planted in crops?*

### **Method**

Look at figures 7, 8, and 9. In 1997, the scientists collected information about potholes only. In 2004, they collected information about potholes and the land surrounding the pothole. Why do you think they expanded the study area around each pothole? *This is an individual question. Students will have to think of why it would be more advantageous to collect information from the land draining water into the pothole in addition to the pothole wetland itself. Students should be encouraged to explore the advantages of studying the larger area.*

Why did the scientists compare restored prairie potholes to natural prairie potholes? *The scientists’ questions were: Do restored prairie potholes provide ecosystem services? If so, how much benefit do they provide as compared to the natural prairie potholes that had never been drained? The scientists could not answer the second question unless they compared restored potholes with natural potholes.*

### **Findings**

Based on the findings reported by the scientists, do you think prairie potholes provide valuable ecosystem services to people? Why or why not? *Students should*

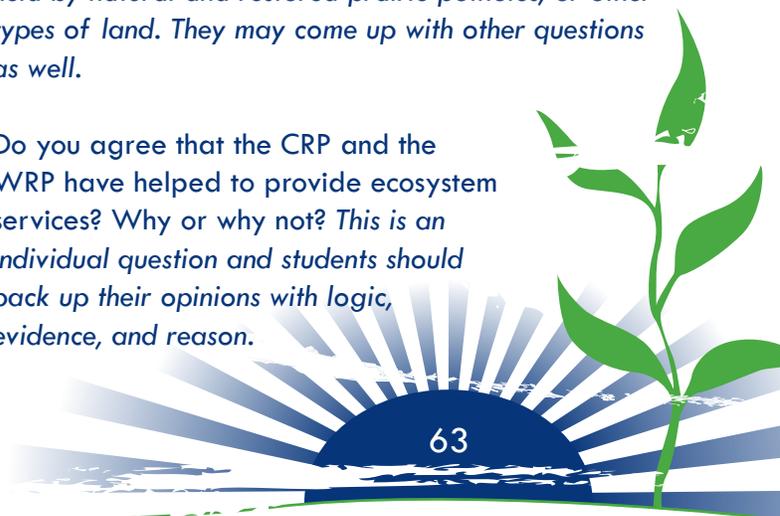
*conclude that prairie potholes provide ecosystem services. These services include a higher variety of plants, help with addressing global climate change, protection from floods, and reduced soil erosion. Students will have to determine if they think these services are valuable. Students should support their determination with logic and sound reasons.*

The scientists reported on four ecosystem services. Based on your reading of this article, what is one other ecosystem service provided by prairie potholes and pothole areas? *Students should remember that potholes provide breeding habitat for waterfowl. If they do not remember this, urge them to reread “Thinking About the Environment.” Students may also be encouraged to imagine other ecosystem services that may be provided by prairie potholes. An example is habitat for other animal species.*

### **Discussion**

Based on the findings of this research, what is another research question the scientists could ask about prairie potholes and prairie pothole areas? (Hint: Reread the findings having to do with carbon and climate change.) *The scientists did not expect to find that the soil of restored prairie potholes did not hold as much carbon as natural potholes. This finding suggests a number of new questions, such as: What is the relationship between the age of a restored pothole and the amount of carbon its soil holds? What might happen if the study was done 10 years from now when the restored potholes are older? Does the soil of restored natural land in other areas of the country also hold less carbon than similar natural areas? Your students may come up with other ideas about comparing the amount of carbon being held by natural and restored prairie potholes, or other types of land. They may come up with other questions as well.*

Do you agree that the CRP and the WRP have helped to provide ecosystem services? Why or why not? *This is an individual question and students should back up their opinions with logic, evidence, and reason.*



# National science Education standards for Ecosystem services Edition of the Natural Inquirer

Journal Article	Toad-Ally Awesome!	What Goes Around Comes Around	Think Outside the Box	Fill Those Potholes!
<b>Science as Inquiry</b>				
Abilities Necessary To Do Scientific Inquiry				
Understanding About Scientific Inquiry				
<b>Life Science</b>				
Structure & Function in Living Systems				
Regulation & Behavior				
Populations & Ecosystems				
Diversity & Adaptations of Organisms				
<b>Earth Science</b>				
Structure of Earth System				
<b>Science in Personal &amp; Social Perspectives</b>				
Natural Hazards				
Risks & Benefits				
Science & Technology in Society				
<b>Science &amp; Technology</b>				
Understanding About Science & Technology				
<b>History &amp; Nature of Science</b>				
Science as a Human Endeavor				
Nature of Science				

## What is the 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 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 Forest Service are scientists whose work is presented in the journal. Forest Service scientists work to solve problems and provide new information about natural resources so that we can make sure our natural environment is healthy, now and into the future.

## What is the U.S. Geological Survey?



The U.S. Geological Survey, or USGS, is the Nation's largest water, Earth, and biological science mapping agency. The USGS collects, keeps track of, evaluates, and provides scientific information about natural resource conditions, issues, and problems. The USGS has 10,000 scientists, technicians, and support staff working in more than 400 locations across the United States. People working with the USGS study the atmosphere, ecology, climate, Earth's characteristics, ecology, geological processes, natural hazards, natural resources, oceans, coastlines, water, plants, and animals. They also produce maps and use maps to help further our understanding of everything on Earth.

For additional information on ecosystem services, visit these Web sites:

**USDA Forest Service Ecosystem Services Web Site**  
<http://www.fs.fed.us/ecosystemservices/>

**Climate Change Calculator**  
<http://www.americanforests.org/resources/cc/>

**Communicating Ecosystem Services**  
<http://www.esa.org/ecoservices/>

**Ecosystem Services Fact Sheet**  
<http://www.esa.org/ecoservices/comm/body.comm.fact.ecos.html>

**Millennium Ecosystem Report**  
<http://www.millenniumassessment.org/en/Index.aspx>

**National Biological Information Infrastructure**  
[http://www.nbio.gov/portal/community/Communities/NBII\\_Home/](http://www.nbio.gov/portal/community/Communities/NBII_Home/)

**The Globe Program**  
<http://www.globe.gov/>

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W. Washington, D.C. 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.



