

Natural Inquirer

**Worming Their Way In:
Invading Earthworms in the
Southeastern United States**



A Natural Inquirer Monograph • Volume 1 • Number 2 • July 2008

The *Natural Inquirer* Monograph, Number 2, July 2008

**Worming Their Way In:
Invading Earthworms in the Southeastern United States**

Produced by

Forest Service

Cradle of Forestry Interpretive Association

Production Staff

Babs McDonald, Forest Service

Michelle Andrews, University of Georgia

Jennifer O'Leary, Cradle of Forestry Interpretive Association

Nickola Dudley, Graphic Design and Illustration, Asheville, North Carolina

Rachel Small, Cradle of Forestry Interpretive Association

Adam Dewitte, Cradle of Forestry Interpretive Association

Forest Service

Gail Kimbell, Chief

Ann Bartuska, Deputy Chief, Research and Development

John Sebelius, Staff Director, Science Quality Services

Jim Hubbard, Deputy Chief, State and Private Forestry

Safiya Samman, Staff Director, Conservation Education

Cradle of Forestry Interpretive Association

Alex Comfort, Executive Director

John Heinitsh, Chairman

Participating scientists

Mac Callaham, Southern Research Station, Forest Service

Paul Hendrix, Odum School of Ecology, University of Georgia

With thanks to

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



Welcome to the *Natural Inquirer* Monographs!

Scientists report their research in a variety of special books. These books enable scientists to share information with one another. A monograph is a book about research that focuses on a single science project. This monograph of a *Natural Inquirer* article was created to give scientists the opportunity to share their research with you and other middle school students. The monograph presents scientific research conducted by scientists in the Forest Service, U.S. Department of Agriculture. If you want to learn more about the Forest Service, you can read about it on the inside back cover of this monograph, or you can visit the *Natural Inquirer* Web site at <http://www.naturalinquirer.org>.



about the natural environment. You will also read about a specific research project. The research article is written in the format that scientists use when they publish research in scientific journals. Then YOU become the scientist as you go through the FACTivity associated with the article. Don't forget to look at the glossary and the special sections highlighted in the article. These sections give you extra information that is educational and interesting.

At the end of each section of the article, you will find a few questions to help you think about what you have read. These questions will help you think like a scientist. They will help you think about how research is conducted. Your teacher may use these questions in a class discussion, or you may discuss these questions in a small group.

Each *Natural Inquirer* monograph will help you explore the exciting world of science and prepare you to become a young scientist. You will learn about the scientific process, how to conduct scientific research, and how to share your own research with others.

All of the research in *Natural Inquirers* is concerned with the natural environment, such as trees, forests, animals, insects, outdoor activities, and water. First, you will “meet the scientists” who conducted the research. Then you will read about one of the many interesting aspects of science and



Visit <http://www.naturalinquirer.org>
for more information, articles, and resources.

Note to Educators

Before using the *Natural Inquirer* monograph, read the Educator Resources section on page 20.

Editorial Review Board At Work

Editorial Comments from the Teen Extreme Camp
Oconee County Georgia Parks and Recreation Department
(Amanda McElroy and Troy Bolden, Counselors)

A collage of black and white photographs showing teenagers sitting at tables, engaged in various activities like reading, writing, and discussing documents. The photos are arranged in a circular pattern, overlapping each other.

I thought it was very well written.

The graphs, charts, and tables are good. Make sure it has more color.

I think they should have different types of activities in the *Natural Inquirer*. And they should put different inventions and show how they work.

It is a very interesting magazine article.

Put it in sections; make it more organized.

I like it because it gives a lot of information about Earth.

I think this is an interesting subject, but you might want to have an activity. For example, a crossword puzzle.

I liked it. It was real cool.

The font size could be bigger (16 font). It is hard for me to read.

Who Are Scientists?

Scientists are people who collect and evaluate information about a wide range of topics.

Some scientists study the natural environment.

To be a successful scientist, you must:

⇒ **Be curious:**

You must be interested in learning.



Dr. Preisler
(from the Invasive Species Edition)

⇒ **Be careful:**

You must be accurate in everything you do.



Dr. Xiao
(from the Urban Forest Edition)

⇒ **Be openminded:**

You must be willing to listen to new ideas.



Dr. Johnson
(from the 1999 Southern Research Station Edition)

⇒ **Be enthusiastic:**

You must be interested in a particular topic.

⇒ **Question everything:**

You must think about what you read and observe.



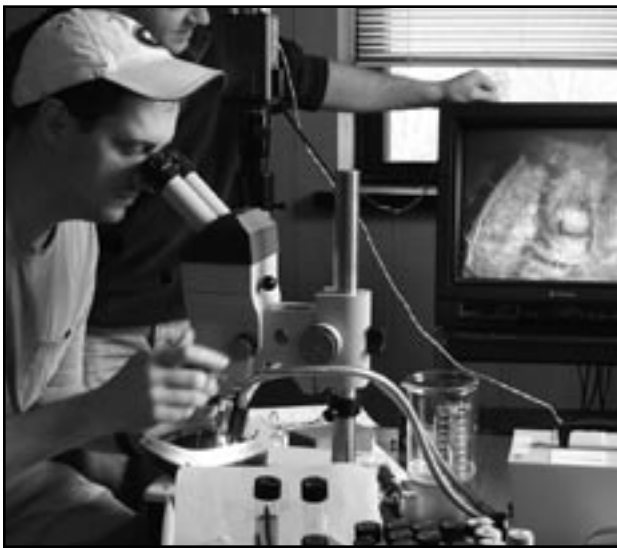
Dr. McKelvey
(from the Invasive Species Edition)



Dr. Cordell
(from the Wilderness Benefits Edition)

Worming Their Way In: Invading Earthworms in the Southeastern United States

Meet the Scientists



Dr. Callaham
Soil Ecologist

My favorite experience was collecting earthworms in a *pristine* cloud forest on top of the highest peak in Puerto Rico. We found earthworms that are found nowhere else in the world. These worms were more than two feet long and bigger around than a tube of Chap Stick®!



Dr. Hendrix
Soil Ecologist

My favorite science experience was conducting an earthworm survey in an old-growth Douglas fir forest in Oregon. The air was cool and smelled like *conifers*. All we found were *native* earthworms under a thick forest floor that was covered with ferns, mushrooms, and slowly decaying logs. It was like walking back in time, to the origins of the mountains, soils, and *organisms* that evolved there.

Note: Italicized words are defined on page 5.

Glossary

pristine (**pris** ten): Remaining in a pure or unspoiled state.

native (**na** tiv): Naturally occurring in an area.

conifer (**kän** uh für): A type of evergreen tree that produces cones and has needle-shaped or scalelike leaves, such as pines, firs, and spruces.

organism (**ôr** gä niz um): Any living thing.

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

taxonomy (tak **on** o me): The science of describing, identifying, and classifying organisms based on their natural relationships. Taxonomic: Having to do with taxonomy.

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

invasive (in **vas** iv): Movement into an area by an object or organism that is likely to cause harm.

leaf litter (**lef** lit ür): The top layer of dead and decaying leaves, small sticks, and twigs that lay on the forest floor.

anglers (**ang** lürz): People who go fishing.

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

forest managers (**för** est **mä** ni jür): Skilled individuals who takes care of natural resources.

Pronunciation Guide

a as in ape

ä as in car

e as in me

i as in ice

o as in go

ô as in for

u as in use

ü as in fur

oo as in tool

ng as in sing

Accented syllables are in **bold**.

Thinking About Science

Earth is home to millions of plant and animal *species*. With so many different types of plants and animals, scientists needed a system for organizing and describing the various species they study. They created a *taxonomic* system that can be used to classify all living things (**figure 1**). Scientists all over the world use the same system. It helps them understand how living things relate to one another, and allows them to share information about their research.

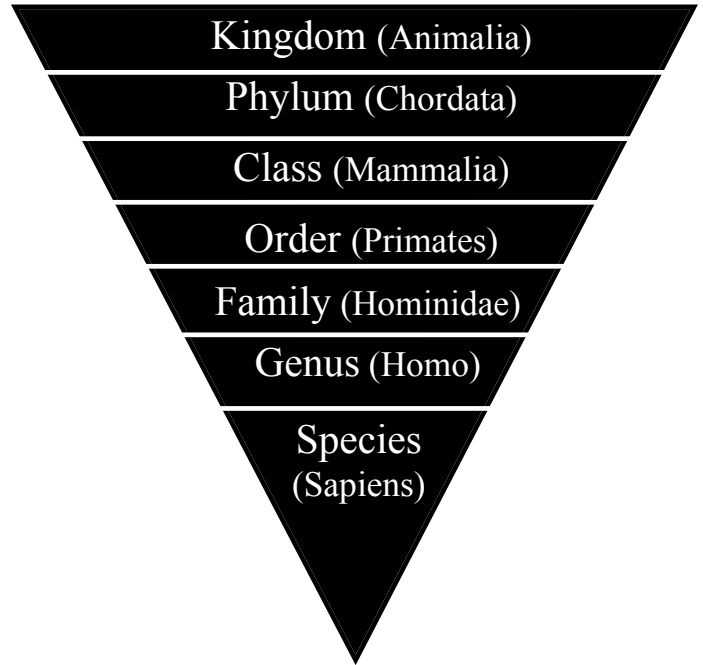


Figure 1. The Pyramid of Classification for all living organisms. Humans are used as an example to show how organisms are grouped and identified (using the taxonomic system). The taxonomic name for humans is in parentheses for every level of classification.

In this study, the scientists discovered a species of earthworm that did not normally live in the area in which it was found. They identified this earthworm by its taxonomic name, and that is the name they used in this study. All living things have taxonomic names, and most living things also have common names. *Homo sapiens* is a taxonomic name. Taxonomic names are always italicized. What is the common name of *Homo sapiens*? If you need a hint, see the caption under figure 1.

Do you think birds are in the same Kingdom as humans? Why or why not? Do you think they are in the same Class as humans? Why or why not?

When do you find it helpful to organize information?

Organization can help you complete tasks at school and at home, like cleaning your room or completing a large project.

- Give an example of when being organized helped you accomplish a task.
- Identify two specific ways you used organization to accomplish the task. Now, identify a task you need to do in the next week.
- How can you organize information to help you accomplish the task?

Thinking About the Environment

Native plants and animals have adapted over a long period of time to live in a particular natural area. They help keep the natural area healthy and contribute to its health by protecting water quality, providing food and shelter for native animal species, and enriching soils for other native plants to grow.



Plants and animals that are not native either move into a new area on their own, are carried on other objects, or are purposely brought into a new area by humans. These *nonnative* plants and animals can upset the natural balance of native plants and animals. When this happens, scientists say that the nonnative plants and animals are *invasive*.

Invasive plants and animals often reproduce more rapidly than native plants and animals. Natural areas lack the animals that would otherwise feed on the invasive plants and animals.

Invasive species, therefore, consume what is needed for survival by native species. This includes things like water, space, and food. Invasive plants and animals can disrupt the balance so much that they put the health of the natural area in danger. In this study, the scientists were interested in learning whether invasive earthworms had invaded a forest.

Introduction

Native earthworms are important to the health of forests. Native earthworms help maintain the forest floor by eating leaves and other plant materials. These earthworms tunnel and eat through soil, making it rich with nutrients for plants to grow. Many animals that live in the forest depend on native earthworms as a source of food.

Scientists have learned that in disturbed soils, nonnative earthworms are found more often than native earthworms. Disturbance occurs during agriculture and when moving soil for road or building construction (**figure 2**). In forest soils where there has not been much disturbance, scientists believed they would find higher numbers of native earthworms compared to nonnative earthworms. The question the scientists wanted to answer in this study was: Are there more native or nonnative earthworms living in undisturbed forest soils in north Georgia?



Figure 2. Construction of new buildings and roads disturbs the native soil.



- How do you think the population of native earthworms changes when an invasive earthworm species moves into its *habitat*? If you need a hint, reread "Thinking About the Environment."
- Why is it important for scientists to determine whether an invasive species has invaded a natural area?

Methods

The scientists set out traps to capture earthworms living in the forests of north Georgia. The scientists used a special kind of trap called a pitfall trap to collect earthworms (**figures 3a, 3b, and 3c**). Pitfall traps are designed to capture small animals and insects that travel along the ground. To make these traps, the scientists dug small holes into the ground. They then put traps into the holes, making sure that the top of each cup was level with the soil on the forest floor. They placed lids on the traps to keep rain water from getting in. Finally, they poured a small amount of liquid preservative into each trap to preserve any earthworms that fell into the traps.



Figure 3a. Pitfall trap.

Figures 3a, 3b, and 3c. The scientists used pitfall traps to collect earthworms. The cover prevented rain from filling the trap. To check the pitfall traps, the scientists removed the cover and collected the earthworms and other animals that happened to crawl inside of it.



Figure 3b. The traps were placed so that the ground's surface was level with the opening. In this way, worms could fall into the trap.



Figure 3c. Lids placed over the traps kept rainfall from getting in.

The scientists placed a total of 1,125 pitfall traps across 20 different locations in north Georgia (**figures 4 and 5**). They placed the traps in areas near rocks, fallen logs, and piles of *leaf litter* where they knew small animals and earthworms were likely to live.



Figure 4. Georgia is located in the Southeastern United States.

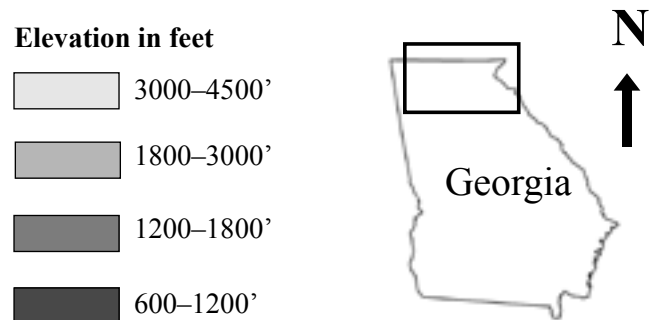
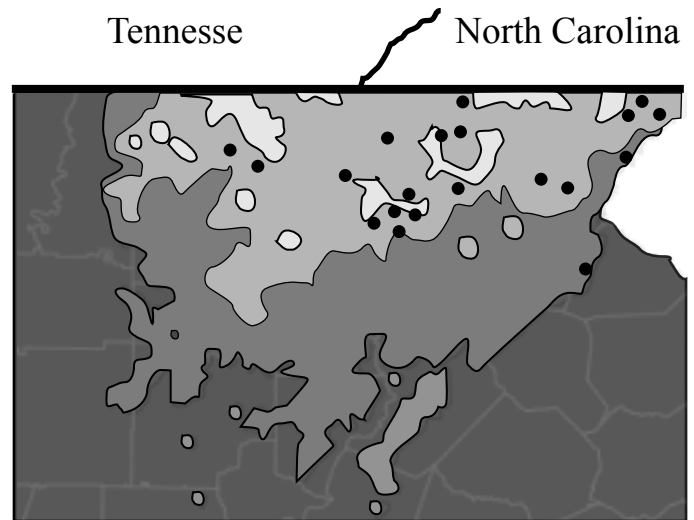


Figure 5. A topographic (to po graf ik) map is a type of map that shows an area's elevation. Elevation is the height of the land above sea level. Some topographic maps use lines to show elevation, but this map uses shading. The lightest areas are the areas with the highest elevation. The darker the area's shading, the lower its elevation.

The dots on this map mark the places where the scientists set the pitfall traps. Look closely at the map. What do you notice about the location of the pitfall traps? What is the range in elevation for the areas where most of the pitfall traps were set?

Number Crunches

If the scientists set a total of 1,125 traps in 20 locations, how many traps (on the average) did they set in each location?

The scientists collected earthworms for 5 months during the summer and fall. They checked the traps every other week. The earthworms that fell into the traps were examined and sorted (**figure 6**). The scientists then determined the species of each individual earthworm. The scientists also counted the total number of earthworm species they collected.



Figure 6. The scientists sorted the earthworms from the other types of animals they found in the pitfall traps before identifying the species of each earthworm.



- Do you think the scientists trapped the types of earthworms that live below the surface of the ground or those that live in the leaf litter that covers the forest floor? Why?
- Why did the scientists identify the species of each earthworm they collected?

Findings

The scientists collected over 600 earthworms from their traps over the 5-month period. More than 75 percent of the earthworms were identified as invasive species. Another 20 percent of the earthworms were too young for the scientists to identify as being either native or invasive. The scientists identified only 4 percent of the earthworms collected as native species.

Of the invasive earthworms collected, 96 percent were from a single species, *Amyntas agrestis* (a min thus uh grest is) (**figure 7**). *Amyntas agrestis* is the taxonomic name for these earthworms, just as *Homo sapiens* is the taxonomic name for humans.

This particular species of earthworm is native to Japan (**figure 8**). *Amyntas agrestis* was first found in California in the early 1900s. However, scientists believe most of these earthworms were brought to the United States in the 1950s when it was popular to plant Japanese trees and other Japanese plants.

The scientists were able to catch large numbers of these earthworms because they live in the leaves that cover the forest floor. In comparison, almost all native earthworms live in the soil. Most of the earthworms you see crawling on the ground, or out after a rain, are not native species. Not all nonnative earthworms, however, eat as much leaf litter as *Amyntas agrestis*.



Figure 7. *Amyntas agrestis*.



Figure 7 (detail). *Amyntas agrestis*.



Figure 8. Japan is located in the northeastern Pacific Ocean.

- Invasive species like *Amyntas agrestis* are often introduced to natural areas through the activities of people. List two activities you think would result in moving *Amyntas agrestis* to new locations.
- Do you think the scientists were surprised at their findings? Why or why not? (Hint: Reread the second paragraph of the Introduction.)

Discussion

The invasive earthworm species found by the scientists is native to Japan. In the 1950s, people brought this species to the United States from Japan. People also helped the species to spread across the United States and into forested areas by using the worms for fish bait. *Anglers* often discard unused earthworms on the ground after fishing. The earthworms quickly become adjusted to their new habitat and begin to reproduce.

Invasive earthworms cause change in the natural areas into which they are introduced. They limit the amount of food


available for native earthworm species. They do this by eating what native earthworm species eat and by occupying the places native earthworms live (**figures 9a and 9b**) *Amyntas agrestis* quickly consumes (eats) large amounts of leaf litter in comparison with other nonnative earthworms. The quick consumption of leaf litter by *Amyntas agrestis* led scientists to consider them an aggressive invasive species.

One of the greatest concerns raised in this research was that invasive earthworms might be changing the forest floor in north Georgia

forests. This decreases the ability of forests to provide habitat for native earthworm species and other animals that live on the forest floor, including salamanders, mice, insects, and snakes.

Scientists should continue to conduct research on invasive earthworms. Scientific research provides *forest managers* with information the managers need to make better decisions. This research also helps managers develop information that discourages people from introducing invasive earthworms to new areas.

In woods without invasive earthworms, the leaf litter...

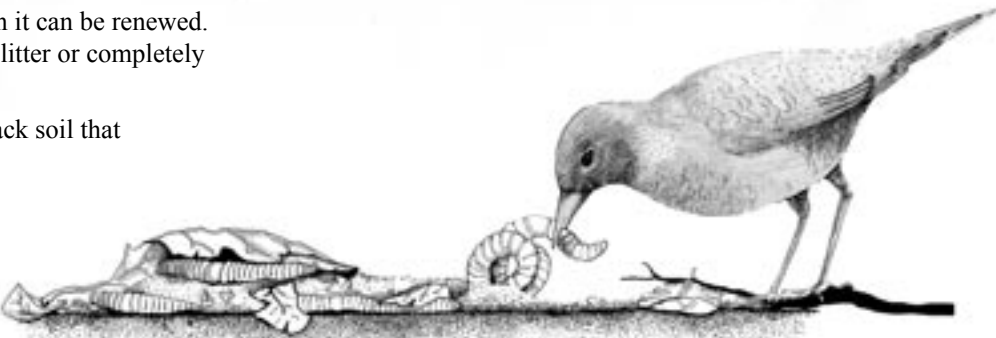


- Holds the soil and prevents erosion
- Protects against temperature extremes
 - Stores nutrients at the surface
 - Protects seeds from animals who might eat them
- Provides a layer where plants can take root
- Provides a habitat for salamanders, toads, and invertebrates

Leaf litter is the thick, spongy layer of leaves and plant materials that cover the forest floor.

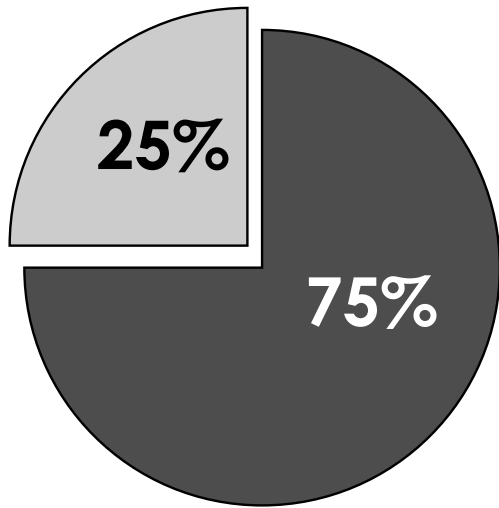
When invasive earthworms are present they...

- “Eat” through leaf litter faster than it can be renewed. This reduces the thickness of the litter or completely eliminates it
- Leave behind a dense layer of black soil that is made of earthworm castings.
- Reduce the ability of the soil to hold moisture
- Increase the nitrogen available to plants
- Affect the animals who used to live in the leaf litter



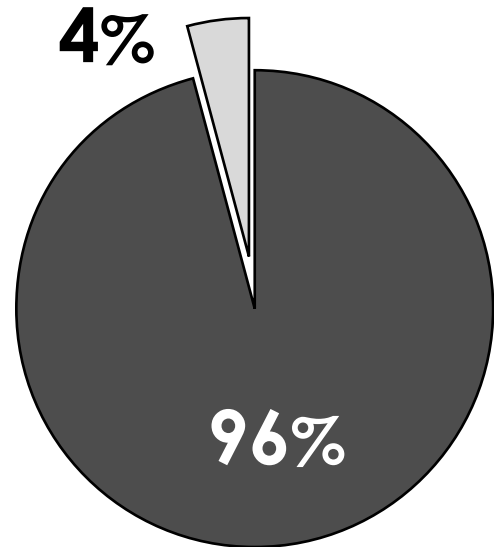
Figures 9a and 9b. These illustrations show how invasive earthworms can affect the forest floor. (Adapted from “Invaders of the Forest,” an original illustration by Steve Mortensen for the Wisconsin Department of Natural Resources).

Number Crunches



Seventy-five percent, or three-fourths of all earthworms collected by the scientists, were invasive species.

How many earthworms were identified as invasive species if the scientists collected a total of 628 earthworms? How many were identified as native species?



Remember that 96 percent of the invasive earthworms were identified as *Amyntas agrestis*. Based on your answers to the previous questions, how many earthworms collected by the scientists were *Amyntas agrestis*? How many were identified as other species of invasive earthworms?

July	August	September	October	November
-------------	---------------	------------------	----------------	-----------------

The scientists collected the earthworms over a 5-month period from July through November.

If a total of 628 earthworms were collected, what was the average number of earthworms collected each month? What was the average number of invasive earthworms collected each month?

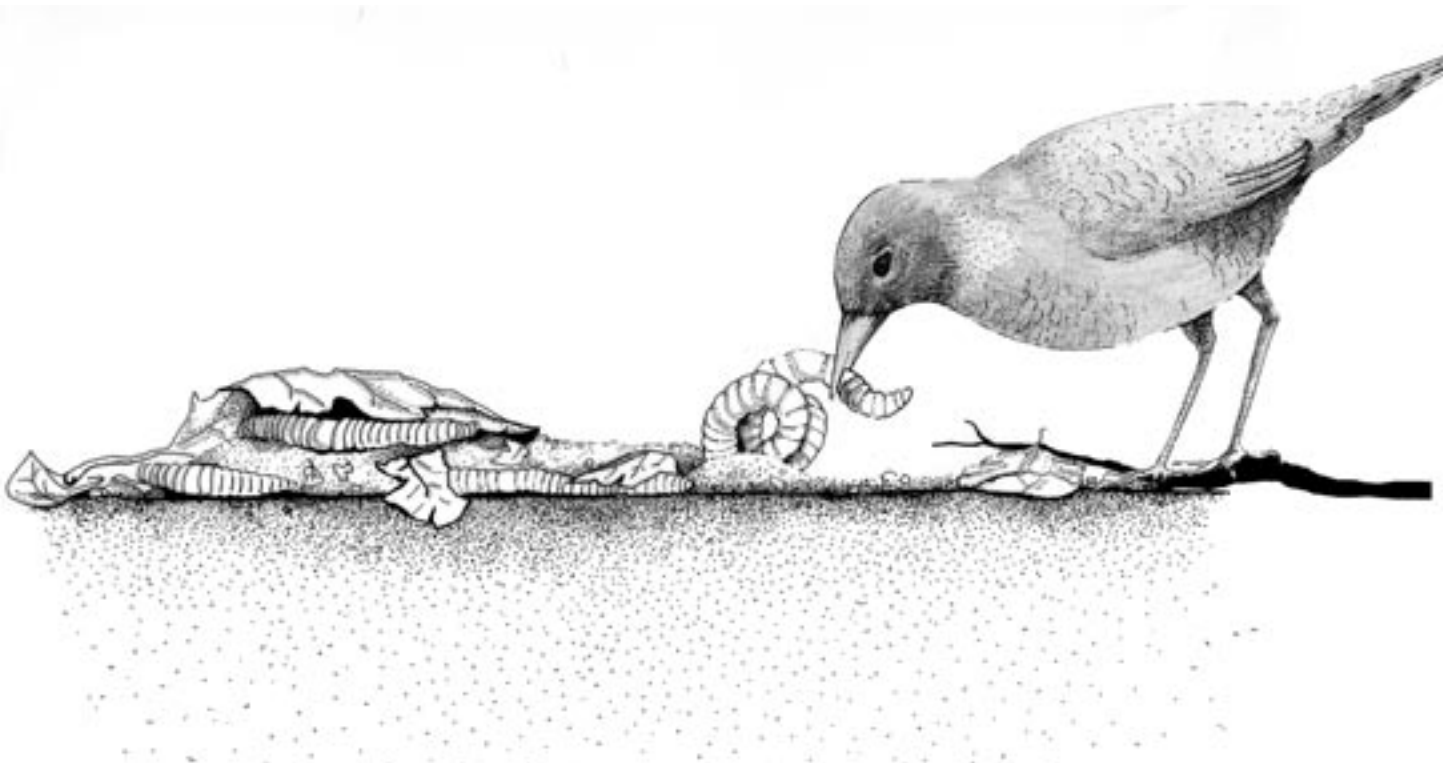


Think about the article you just read. You learned that many of the native species must move to a new area when invasive species take over an area. Look carefully at the drawing below. Do you think that all native species are harmed when invasive species are present? Why or why not? Do you think a native species might benefit in some way? Why or why not?

Let's say a native species benefits in some way from the arrival of an invasive species. Do you think the environmental balance can be upset even when a native species benefits? Why or why not?

This article was adapted from: Callaham, M. A., Hendrix, P. F., and Phillips, R. J. (2002). Occurrence of an exotic earthworm (*Amyntas agrestis*) in undisturbed soils of the southern Appalachian Mountains, USA. *Pedobiologia*, Vol. 47:466-470. http://www.srs.fs.usda.gov/pubs/ja/ja_callaham001.pdf

- Would decreased amounts of leaf litter affect other animals living in the forest? How?
- Pretend that you are the forest manager for an area of forest that has been invaded by invasive earthworms. What are some things you could do to stop or slow the spread of these earthworms into your forest?



FACTivity

Time: One class period

Needed: Plastic cups, trowel, water, small amount of dishwashing liquid, rulers, plastic tweezers, various sizes of plastic or glass containers, pencils, and copies of the student worksheet on page 16. The total number needed of these supplies will depend on how many groups of students are doing the FACTivity. Each group should have one ruler, two pairs of tweezers, and plastic containers, as well as a pencil and worksheet for each member of the group.

Your teacher will place several pitfall traps in your schoolyard at least 24 hours and up to 48 hours before the activity. He or she should set out one trap for every team of students doing the activity. If there is time, your teacher may have teams of students place these traps 1 to 2 days before the FACTivity.

The teacher should set the traps in a range of settings (for example, near the forest's edge, an open field, near a stream or other water feature), depending on the size of the area being used for the activity. Using a trowel, your teacher will dig a hole large enough to bury a plastic cup up to the rim. It is best to find areas rich in leaf litter or compost, as this is the preferred habitat of earthworms.

Your teacher will then place 2 inches of water in the bottom of each cup, along with a tiny drop of dishwashing liquid. The teacher should place several small stones

around the rim of the cup and cover with a small piece of wood to protect the animals that fall into the trap from rain. A small plastic plate, weighted down with a small rock, can also be used for the lid. Remember to leave enough space for organisms to enter the trap. The cover will prevent the cup from filling with water and drowning any organisms that fall into the trap. If any leaf litter was removed to place the trap, replace the leaf litter around the trap. If time is available, students may help the teacher set the traps.

The questions you will answer with this FACTivity are:

- 1) Are earthworms a part of your school yard habitat?
- 2) How much difference exists among the types of soil-dwelling organisms that live in your school yard?

(Note: This FACTivity is best to do after a rainfall event in the fall and spring months when soil-dwelling organisms are more active.)

The method you will use to answer the questions is:

1. Your teacher will divide the class into groups of three. Each group will work with a different trap. You should prepare the study area by placing several containers around the trap in which to sort the organisms.

2. Begin by recording the site conditions surrounding the trap. Record weather conditions over the past day. These could affect earthworm activity. Use the ruler to measure the depth of leaf litter in inches surrounding the trap. Use the chart on this page to observe and record the site conditions.
3. Examine the Pitfall Trap Survey Table. Notice the categories of organisms listed in the table. These are the categories into which you will sort your captured organisms.

4. Remove the lids from the traps. Using the tweezers, carefully remove the trapped organisms one at a time. Remember that the organisms are an important part of your school yard habitat and that they should be returned to their habitat the same way you found them. The containers should be used to sort the organisms. Record what you find and how many of the various types of organisms you find on the Pitfall Trap Survey Table.

(Warning: Be careful when handling the organisms as they could have a harmful bite or sting. Do not use your fingers to handle the organisms!)

Pitfall Trap Site Collection				
Date _____	Time _____			
Weather Observations (circle all that apply)				
Conditions over the past 24 hours	sunny	cloudy	windy	
	cool	warm	rain	other
Current conditions	sunny	cloudy	windy	
	cool	warm	rain	other
Vegetation				
Type of vegetation surrounding the trap	grass	flowers	shrubs	trees
Leaf Litter				
Measure the depth of the leaf litter surrounding the trap _____ in.				

Pitfall Trap Survey		
Type of Organism	Number of Individuals	Total Number Collected
Insect		
Earthworm		
Other		

Total number of all collected organisms	_____
Percentage of insects	_____
Percentage of earthworms	_____
Percentage of other	_____
	100%

5. Inside the classroom, count the number of individual organisms you collected in each category. Add these numbers to determine the total number of organisms collected by your class. Use these numbers to determine the percentage that each type of organism represents among the animals you trapped. If possible, reproduce the Pitfall Trap Survey Table and percentages on the white board so that the entire class can see it.
6. After you have completed counting the number of organisms collected, return the organisms to the area where they were collected. Remove the pitfall traps and fill the holes with soil.
7. Your teacher should lead a class discussion to talk about the results of the activity. Here are some questions that he or she may use to start the discussion:
 - How did the percentage of earthworms compare with the percentages of other organisms that were collected from the traps?
 - Based on what you know, do you think the earthworms collected from the traps are native to the area or an introduced, invasive species? Why or why not?
 - Was there a relationship between the amount of leaf litter surrounding the traps and the number of earthworms collected from that trap? If so, what was the relationship?
 - Why would the amount of leaf litter found in an area provide a clue as to how many earthworms might be expected to be found living in that area?

- Do you think the number of earthworms living in your school yard has an impact on the other organisms living there? Why or why not?

8. Answer the two questions asked at the beginning of this FACTivity.
9. As a class, make a list of at least three weaknesses of the inquiry process you just completed. Discuss what you could do differently to improve the study. (For example, a weakness might be that the traps were left out only overnight. An improvement might be to collect organisms from traps left out for 3 days.)

FACTivity Extension

(or in cooperation with the Art teacher)

Time: One class period

Need: Poster paper, colored markers

One of the ways invasive earthworms travel to new areas is through the actions of anglers. Create colorful posters to educate anglers about invasive earthworms. These posters should recommend that worms be disposed of properly (not discarded on the ground). Your teacher may set up a display of your posters in your school hallway or in a local library or other public area.

Alternative **FACT**ivity (Indoors)

Time: One class period

Need: Blank paper and pencils

The question you will answer in this

FACTivity is: How are taxonomic structures useful to people?

Review the taxonomic structure for *Homo sapiens* in **figure 1**. If you want more information on taxonomic structure, search the Internet using the words “taxonomic structure.”

Your teacher should divide your class into small groups. Each small group will develop a taxonomic structure for one of the following categories:

Movies

Books

Vehicles

Musical Instruments

Periodical Publications (magazines)

First, identify at least three different examples from your category to use in your taxonomy. Each example should be different from the others. For example, under musical instruments you might identify drums, piano, and flute. These are different kinds of musical instruments. Then, you will develop a taxonomic structure using your three examples. Take 15 minutes to develop the taxonomic structure. Have one student in your group diagram and label your

taxonomic structure on a blank sheet of paper. Within your group, take 10 minutes to discuss how your taxonomic structure might be used in today’s society. For example, your taxonomic structure may help people to compare and contrast any of the items you classified.

Your teacher should also lead a class discussion about your taxonomic structures (10 minutes).

Questions to consider include:

- What were some of the challenges you faced as you developed your taxonomic structure?
- Share some of the uses you identified for your taxonomic structure. What are the similarities and differences in uses identified by different groups?
- Now answer the question posed at the beginning of this FACTivity.



If you are a PLT-trained educator, you may use Activity #24 Nature’s Recyclers and Activity #47 Are Vacant Lots Vacant?

“Worming Their Way In” Word Search

LAN
BSRFRKZ
NOSEICEPS
XNQFTJQSLHS
FORESTMANAGER
ORGANISMBTRNO
ICRXKNLOIFZQQAR
WSROEIQFTEVISAVNI
MYMONOXATNX YJBTJY
ZABMLKITEVITANNONHV
RTHMXHCF LMT PAMHHWAB
QEOSH
LCRIE
USNRJ
NWUPX
HHZYI

Complete the 12 sentences below by writing the correct word from the article glossary. Then, find the glossary words in the Word Search puzzle by circling them. The words may be diagonal, from left to right or right to left, and up to down or down to up.

1. Person who goes fishing. _____
2. Environment where a plant or animal naturally grows and lives. _____
3. A type of evergreen tree that produces cones and has needle-shaped or scalelike leaves, such as pines, firs, and spruces. _____
4. The top layer of dead and decaying leaves, small sticks, and twigs that lay on the forest floor. _____
5. Skilled individual who takes care of natural resources. _____
6. Not naturally occurring in an area. _____
7. Movement into an area by an object or organism that is likely to cause harm. _____

8. Remaining in a pure or unspoiled state. _____
9. Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure. _____
10. Any living thing. _____
11. Naturally occurring in an area. _____
12. The science of describing, identifying, and classifying organisms based on their natural relationships. _____

***Note to Educators: Please feel free to make copies for other appropriate educational opportunities.

Educator Resources

The *Natural Inquirer* is a science education journal for middle school students. A journal contains six to seven articles, rewritten from the original published scientific paper. This *Natural Inquirer* Monograph contains just one article. When you use this monograph in your classroom, you may take advantage of the educational resources available in the monograph and on the Web site. The monograph stands alone as a classroom resource. The following sections will provide everything you need to use this monograph in your classroom:

Meet the Scientists: Introduces the scientists whose research is presented. This section can be used to discuss careers in science.

Glossary: Introduces potentially new terms used in the monograph. Visit <http://www.naturalinquirer.org> for a word search associated with this glossary.

Thinking About Science: Provides one idea about the nature of scientific inquiry.

Thinking About the Environment: Provides background information to introduce the topic studied by the scientists.

Introduction: Introduces the problem or question the scientists addressed.

Method: Presents the method used by the scientists to collect and analyze their data.

Findings: Presents the results of the research.

Discussion: Places the findings into the context of the original problem or question.

Reflection Sections: These questions are not a test! They are placed after the Introduction, Method, Findings, and Discussion sections to help students critically think about what they have read. They can also be used to informally assess student comprehension.

FACTivity: Presents an activity that can be done in the classroom and out-of-doors.

Citation: Gives the original article citation.

Lesson Plan: Presents a lesson plan for using the *Natural Inquirer* monograph in the classroom.

Correlation to Science Education Standards:

Presents Science Competency Goals for North Carolina (7th grade) and National Science Education Standards (grades 5-8) that can be addressed by the monograph.

Let us know what **YOU** think about the *Natural Inquirer*. Visit <http://www.naturalinquirer.org> and fill out the online educator evaluation form. Your input helps us to continually improve the *Natural Inquirer*.

If you are interested in having your 7th grade science class featured as an Editorial Review Board in a future edition of the *Natural Inquirer*, please contact:

Babs McDonald at bmcDonald@fs.fed.us and put “Educator feedback” in the subject line.

If you are an educator in western North Carolina, please contact Jennifer O’Leary at joleary22@msn.com.

For more information about the *Natural Inquirer*, to order additional copies, or to explore educator and student resources for using the journal, visit
<http://www.naturalinquirer.org>

For other information or assistance, contact

Babs McDonald at bmcDonald@fs.fed.us. Please put “Educator Feedback” in the subject line. Physical address: 320 Green St., Athens, GA 30602-2044, 706-559-4224.

Lesson Plan

Time: Two or three class periods

Need for each student: *Natural Inquirer* Monograph and copies of graphic organizers.

A template for four graphic organizers is presented on page 23. Graphic organizer #5 is the summary organizer. It is the last organizer the students will use, and it is presented on page 24. Graphic organizers 1–4 are identical. Make 4 copies of this template for each team of two students. Have students label each template with one of these titles: Introduction, Method, Findings, Discussion.

In this lesson, pairs of students will create a 60- to 90-minute radio broadcast/podcast based on the article.

Visit <http://www.naturalinquirer.org> for information on how to record your broadcasts as podcasts. (This requires special, but not expensive, equipment.)

Day 1

Explain to your students that they will be creating their own radio broadcast/podcast of the information being presented in the *Natural Inquirer* article. Using the graphic organizers along with their reading, students will summarize the article. Then, each student pair will write and present a script based on a scenario they choose. Possible scenarios include:

1. Radio report of the research
2. Discussion between two scientists
3. News report—breaking news about the research
4. An interview with the scientist who did the research
5. Song/rap/poem written from the article

6. Broadcast from the perspective of the plant or animal being studied
7. Broadcast made by the plant or animal being studied
8. Broadcast in the future based on this as past research

As a class, read the introductory material (Title, Meet the Scientists, review glossary, Thinking About Science, and Thinking About the Environment). You may have one student read each paragraph. Check student comprehension about the general topic of the article. (In this case, invasive species and how they may impact a native ecosystem.)

Divide students into pairs. Give each pair a copy of graphic organizers 1-5. If students have not yet done so, have them label the four templates to match each of the four article sections (i.e., Introduction, Method, Findings, Discussion).

First, students will read the research article and summarize it using the graphic organizers. Each organizer should be used with the corresponding article section. This can be done as a class or students may read in pairs.

As an option, you may stop the class between sections and have them discuss the reflection questions.

By the time students have completed the five graphic organizers, they should have four summary paragraphs, one written for each section.

Note that depending on the class progress, this could take more than 1 day to complete.

Note: Audio examples of *Natural Inquirer* podcasts created by students are available on the *Natural Inquirer* website, <http://www.naturalinquirer.org> under “Education Resources.”

Day 2

In their pairs, students should decide on a scenario. Once they have done this, they should develop their script in writing. The script should be no longer than 150–175 words. The following are some additional guidelines to share with your students:

1. Your broadcast/podcast should express something you found important or interesting about the article. It should also express something you think your listeners will find interesting or important. **Include information from each of the four sections of the article, using your summary paragraphs as a guide.**
2. Be accurate. Check your facts by using the article, the Web, a dictionary, encyclopedia, or other source.
3. Involve the whole team.

4. Use music or other sounds if possible. (Note that this may be possible only if you have sufficient time.)
5. Time limit for the broadcast is 90 seconds.

Give students 35 minutes to complete their script. If students are having difficulty, you may need to give them more time.

Once the scripts are complete, have each pair present their broadcast to the class. If possible, record the broadcasts.

Assessment: During group work, student teamwork skills can be informally assessed. Student achievement should be assessed during the presentations. You can use the Assessment Rubric shown below.

Note: This lesson plan can be used with any Natural Inquirer article.

Assessment Rubric

	Poor 1	Fair 2	Good/Satisfactory 3	Exemplary 4	Score
Team Work	Accepted assigned role but did not contribute to overall assignment.	Could have contributed more.	Worked well with partner.	Excellent cooperation and contribution to teamwork. Developed ideas with partner.	
Understanding of Material	Did not demonstrate understanding of subject matter.	Demonstrated limited amount of understanding of subject matter.	Demonstrated understanding of subject matter.	Demonstrated exemplary knowledge of subject matter.	
Organization	Presentation was not coherent, lacked thought and appropriate preparation.	Presentation needed more preparation and organization.	Presentation was satisfactory.	Presentation was excellent.	
Grammar/Punctuation	Too many grammatical/punctuation errors.	Needed to demonstrate better use of punctuation and grammar.	Proper use of grammar and punctuation, few errors.	Very well organized. No grammatical or punctuation errors.	
Creativity	Did not demonstrate any creativity.	Demonstrated limited creativity.	Creative.	Very creative.	

The Natural Inquirer Graphic Organizer

1 In the ovals, write two (four) things I (we) found out:

2 Place a star by the one (two) that are most interesting.

3 In the arrow(s), write the question or problem the scientist wanted to answer or solve. (There may be only one.)

4 In the square(s), write something that any of the items in the ovals or arrows remind you of.

5 In the circle(s), write any questions you still have.

Student 1

Student 2

6 Draw lines connecting the shapes that contain information related to each other.

Based on your Graphic Organizer for the Introduction Section, write a summary paragraph that is 3-4 sentences long.

Based on your Graphic Organizer for the Method Section, write a summary paragraph that is no more than 3-4 sentences long.

Based on your Graphic Organizer for the Findings Section, write a summary paragraph that is no more than 3-4 sentences long.

Based on your Graphic Organizer for the Discussion (or Implications) Section, write a summary paragraph that is no more than 3-4 sentences long.

Possible Answers to the Reflection Questions

Note to Educator: The purpose of the Reflection Questions is to encourage students to think critically about what they have read. The following “answers” are only suggestions to assist you in using these questions in the classroom. You may use the student answers to these questions as an informal assessment tool.

Introduction

How do you think the behavior of a native earthworm changes when an invasive earthworm species moves into its habitat?

Invasive earthworms consume large amounts of leaf litter, which covers the forest floor. Native earthworms also feed on leaf litter. With less food available, native species of earthworms may have to move to a new location where food is more abundant in order for them to survive.

Why it is important for scientists to determine whether an invasive species has invaded a natural area?

Invasive species can cause harmful changes to natural environments. It is important for scientists to understand these impacts so that they can help find ways to reduce impacts.

Method

Do you think the scientists trapped the types of earthworms that live below the surface of the ground or those that live in the leaf litter that covers the forest floor? Why?

The majority of the earthworms collected by the scientists were earthworms that live in the leaf litter that covers the forest floor. As suggested by figure 3, pitfall traps lie flush with the ground just below the leaf litter. Only earthworms crawling on the ground would be able to enter the trap.

Why did the scientists identify the species of each earthworm they collected?

The scientists identified the species of each earthworm they collected to determine if there were greater numbers of native earthworm species or invasive earthworm species. The scientists also needed the information to determine which types of invasive species they were collecting.

Findings

Invasive species like *Amyntas agrestis* are often introduced to natural areas through the activities of people. List two activities you think would result in moving *Amyntas agrestis* to new locations.

Students should consider activities such as moving soil from one location to another, using worms for fish bait, and soil getting stuck on tires.

Do you think the scientists were surprised at their findings? Why or why not? (Hint: Reread the second paragraph of the Introduction.)

Yes, the scientists should have been surprised because they believed they would find native earthworms in undisturbed forest soils.

Discussion

Would decreased amounts of leaf litter affect other animals living in the forest? How?

Yes. Decreased amounts of leaf litter can lead to changes in native vegetation, which in turn can result in decreases in the kinds and amounts of food that are available for wildlife. Decreased depths of leaf litter also result in less cover for small animals to use when avoiding predators.

Pretend that you are the forest manager for an area of forest that has been invaded by invasive earthworms. What are some things you could do to stop or slow the spread of these earthworms into your forest?

Educate anglers about the impact of discarding their unused fishing bait on the ground. Suggest alternative types of bait for anglers to use or encourage them to buy from places that sell native species of earthworms as bait. You could post this information on signs, brochures, and bulletin boards.

Number Crunches

Based on the graph above, how many earthworms were identified as invasive species if the scientists collected a total of 628 earthworms? **471**

How many were identified as native species? **157**

Based on your answers to the previous questions, how many earthworms collected by the scientists were *Amyntas agrestis*? **452** (answer is rounded)

How many were identified as other species of invasive earthworms? **19** (answer is rounded)

If a total of 628 earthworms were collected, what was the average number of earthworms collected each month? **126** (answer is rounded)

What was the average number of invasive earthworms collected each month? **94** (answer is rounded)

Which science education standards can be addressed through this monograph?

STANDARD	Lesson Plan	FACTivity
Science Competency Goals for North Carolina (7th grade)		
Goal 1: The learner will design and conduct investigations to demonstrate an understanding of scientific inquiry.		
1.01 Identify and create questions and hypotheses that can be answered through scientific investigations.	X	X
1.04 Analyze variables in scientific investigations: Identify dependent and independent variables Manipulate variables Describe relationships between variables	X	X X
1.05 Analyze evidence to: Explain observations Make inferences and predictions Develop the relationship between evidence and explanation	X X X	X X X
1.06 Use mathematics to gather, organize, and present quantitative data resulting from scientific investigations: Measurement Analysis of data		X X
1.08 Use oral and written language to: Communicate findings Defend conclusions of scientific investigations	X X	X X
1.10 Analyze and evaluate information from a scientifically literate viewpoint by reading, hearing, and/or viewing: Scientific text Articles	X X	X X

STANDARD

Lesson Plan FACTivity

National Science Education Standards Addressed by This Article

Science as Inquiry

Abilities necessary to do scientific inquiry:

- Identify questions that can be answered through scientific investigation.
- Design and conduct a scientific investigation.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.

X

X

X

X

X

X

X

Life Science

Regulation and behavior:

- All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing environment.
- Behavior is one kind of response an organism can make to an internal or environmental stimulus.
- An organism’s behavior evolves through adaptation to its environment.

X

X

X

X

Populations and Ecosystems:

- A population consists of all individuals of a species that occur together at a given place and time.
- Populations of organisms can be categorized by the function they serve in an ecosystem.
- The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.

X

X

X

X

Diversity and Adaptations of Organisms:

- Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry.
- Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.

X

X

Science and Technology

Understanding About Science and Technology:

- Science and technology are reciprocal. Science helps drive technology, as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and technique. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry, and analysis.

X

X

Science in Personal and Social Perspectives

Natural Hazards:

- Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.

X

Science and Technology in Society:

- Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research.

X

History and Nature of Science

Science as Human Endeavor:

- Women and men of various social and ethnic backgrounds—and with diverse interests, talents, qualities, and motivations—engage in the activities of science, engineering, and related fields, such as the health professions.
- The work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity—as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

X

X

X

Nature of Science:

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.

X

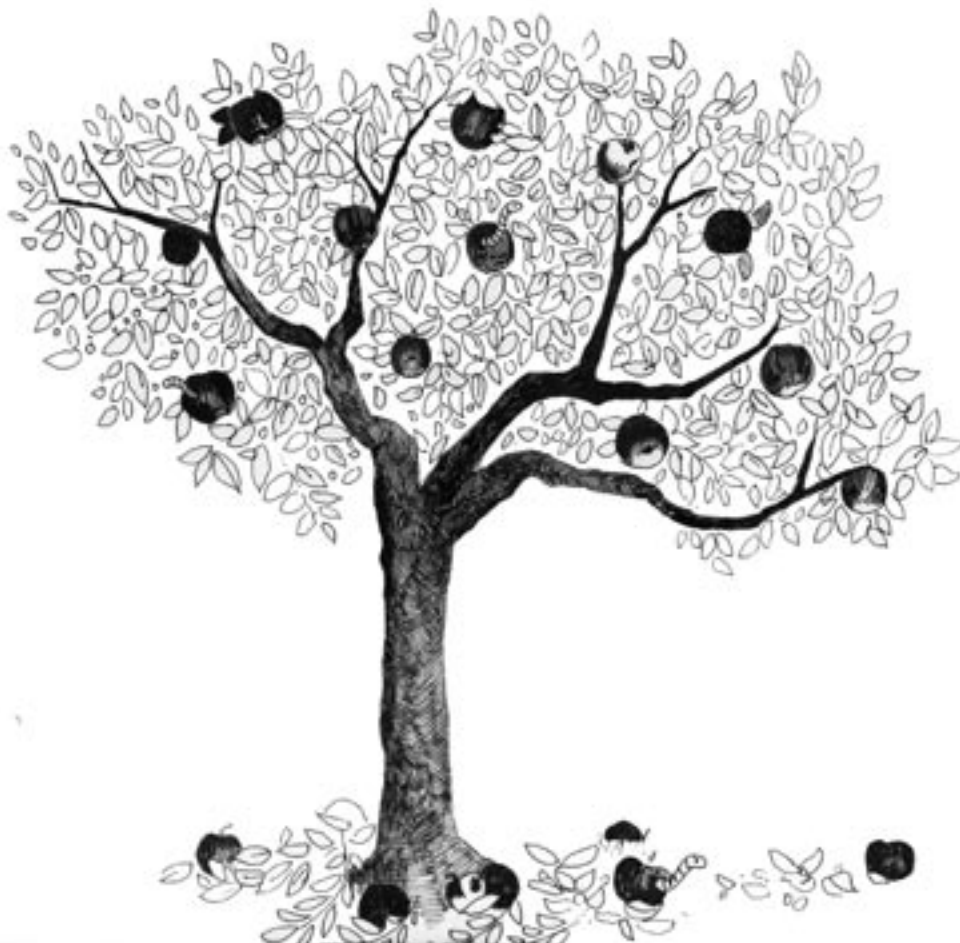
X

Educators! We need your help!

The *Natural Inquirer* seeks to continually improve by asking educators and students to review each article prior to publication. We invite your comments on any aspect of the *Natural Inquirer* publication and Web site. Please let us know what you like and what we can improve. We also want to know whether the lesson plans and FACTivities are useful to you and how they can be improved. You can contact us by visiting our Web site (<http://www.naturalinquirer.org>) and click on “Educator Comments.”

If your students create podcasts from this or any *Natural Inquirer* article, please let us know so that we can post the podcasts on the *Natural Inquirer* Web site. You can do this through the Educator Comment section of the Web site, or send an email to bmcdonald@fs.fed.us and put “Educator Feedback” in the subject line.

Thank you for your contribution!





What Is the Forest Service?



The Forest Service is an agency of the United States Department of Agriculture. It is made up of thousands of people who care for the Nation's forests and grasslands. The Forest Service manages over 150 national forests and almost 20 national grasslands. National forests, like national parks, provide places for people to recreate, they provide homes for wildlife, and they provide clean water and air for everyone. 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 this monograph (**mon o graf**). These scientists work to solve problems and provide new information about natural resources so we can make sure our natural environment is healthy, now and into the future.

Learn more about the Forest Service by visiting

<http://www.fs.fed.us>



What Is the Cradle of Forestry Interpretive Association?

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

Learn more about the CFIA by visiting

<http://www.cradleofforestry.org>

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.

Editorial Review Board



Web Resources

Natural Inquirer: <http://www.naturalinquirer.org>

Forest Service Conservation Education: <http://www.fs.fed.us/outdoors/nrce/>

Cradle of Forestry Interpretive Association: <http://www.cradleofforestry.org>

Forest Service Recreation: <http://www.fs.fed.us/recreation>

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

Invasive Earthworms in Minnesota: <http://www.dnr.state.mn.us/invasives/terrestrialanimals/earthworms/index.html>

Worm Facts: <http://www.urbanext.uiuc.edu/worms/facts/index.html>

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

