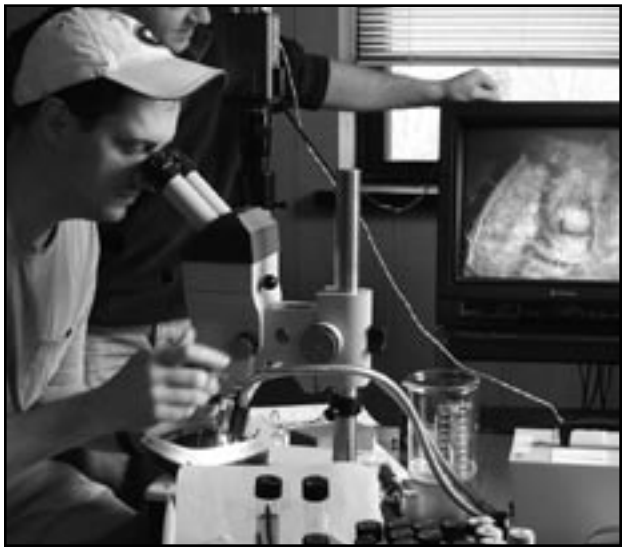
Worming Their Way In:
Invading Earthworms in the Southeastern United States

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** te<u>n</u>): Remaining in a pure or unspoiled state.

native (**n<u>a</u>** 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<u>e</u>** se<u>z</u>): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure.

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

nonnative (nän **n<u>a</u>** tiv): Not naturally occurring in an area.

invasive (in **v<u>a</u>s** iv): Movement into an area by an object or organism that is likely to cause harm.

leaf litter (**l<u>e</u>f** lit ür): The top layer of dead and decaying leaves, small sticks, and twigs that lay on the forest floor.

anglers (**a*ng*** 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

<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**.

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.

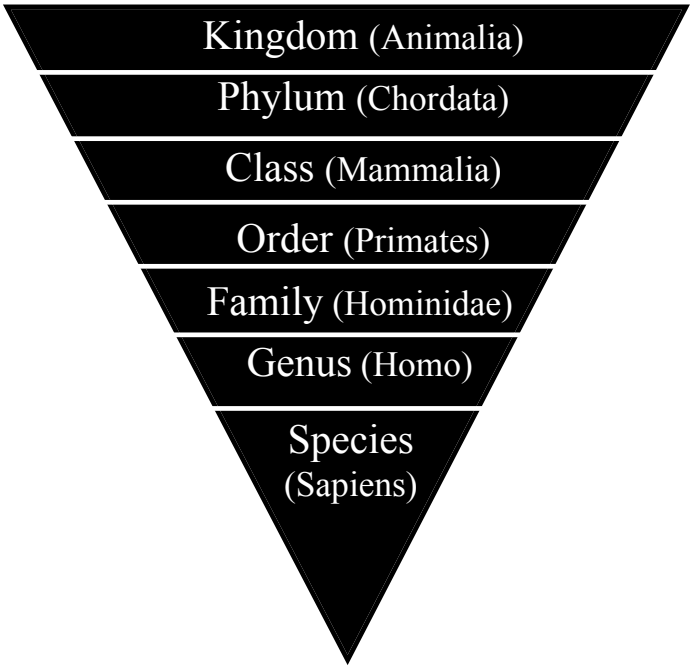


Figure 1. The Pyramid of Classification for all living organisms. Humans are used as an example to show how organisms are grouped and identified (using the taxonomic system). The taxonomic name for humans is in parentheses for every level of classification.

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?

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.

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.

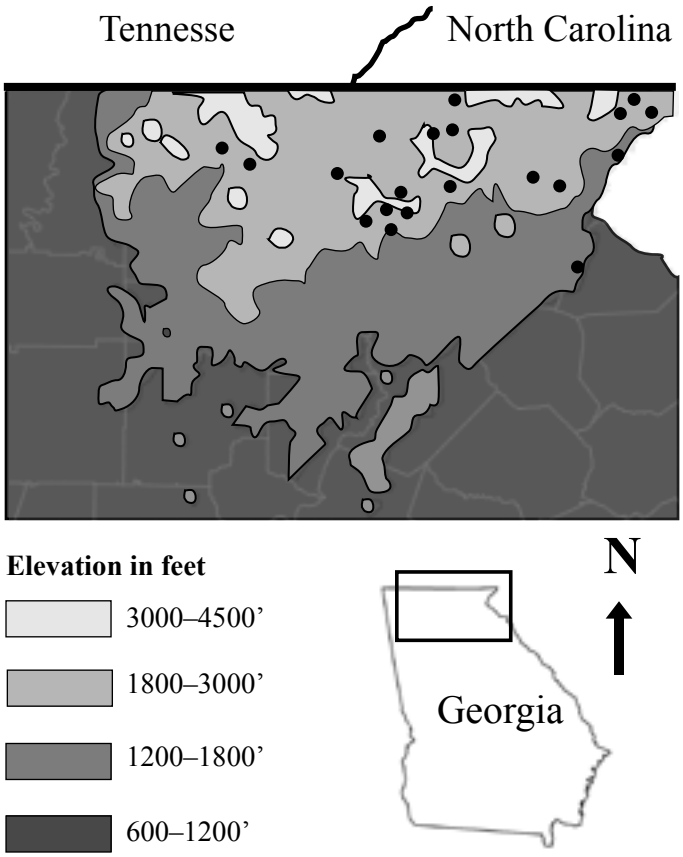


Figure 5. A topographic (to po **graf** ik) map is a type of map that shows an area’s elevation. Elevation is the height of the land above sea level. Some topographic maps use lines to show elevation, but this map uses shading. The lightest areas are the areas with the highest elevation. The darker the 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, ***Amynthas agrestis*** (a **min** thus uh **grest** is) (**figure 7**). *Amynthas 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**). *Amynthas 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 *Amynthas agrestis*.

Figure 7. *Amynthas agrestis.*

Figure 7 (detail). *Amynthas agrestis.*

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

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

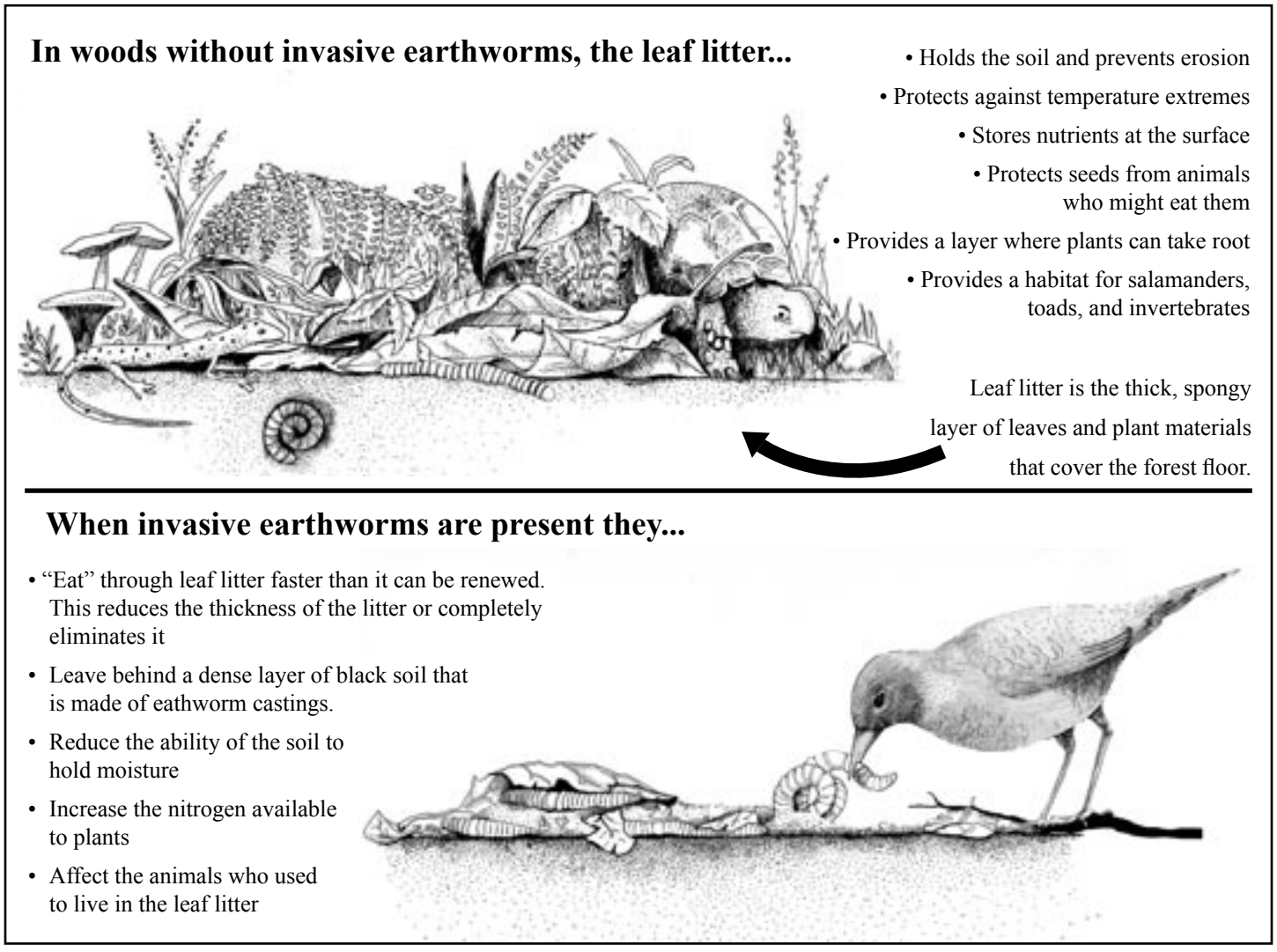
The invasive earthworm species found by the scientists is native to Japan. In the 1950s, people brought this species to the United States from Japan. People also helped the species to spread across the United States and into forested areas by using the worms for fish bait. *Anglers* often discard unused 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)** *Amynthas agrestis* quickly consumes (eats) large amounts of leaf litter in comparison with other nonnative earthworms. The quick consumption of leaf litter by *Amynthas agrestis* led scientists to consider them an aggressive invasive species.

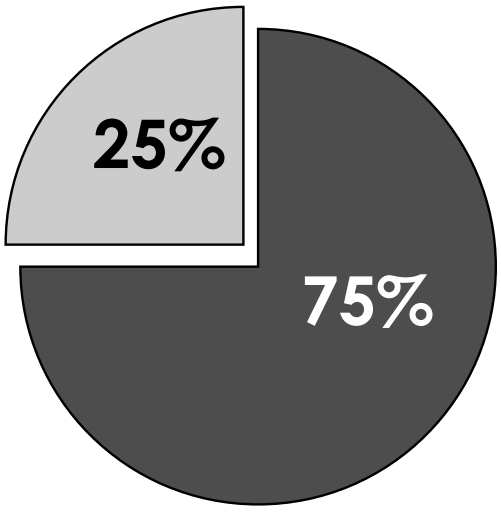
One of the greatest concerns raised in this research was that invasive earthworms might be changing the forest floor in north Georgia forests. This decreases the ability of forests to provide habitat for native earthworm species and other animals that live on the forest floor, including salamanders, 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.



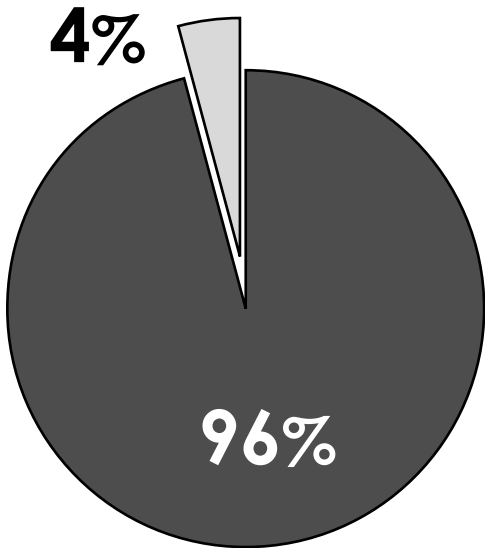
Figures 9a and 9b. These illustrations show how invasive earthworms can affect the forest floor. (Adapted from "Invaders of the Forest," an original illustration by Steve Mortensen for the Wisconsin Department of Natural Resources).

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 *Amynthas agrestis*. Based on your answers to the previous questions, how many earthworms collected by the scientists were *Amynthas 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.

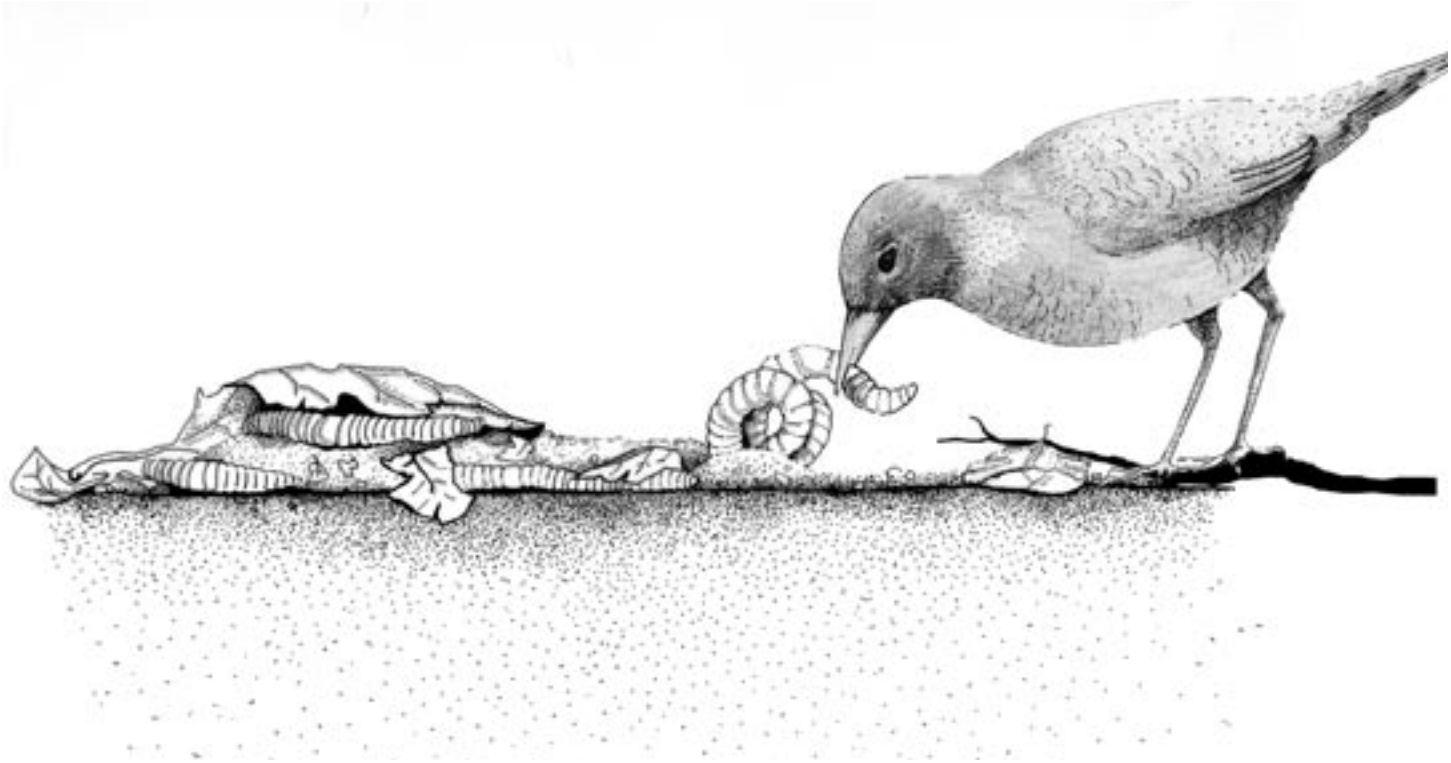
If a total of 628 earthworms were collected, what was the average number of earthworms collected each month? What was the average number of invasive earthworms collected each month?

- **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?**

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 (*Amynthas 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



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 cool	cloudy warm	windy rain	other
Current conditions	sunny cool	cloudy warm	windy 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?