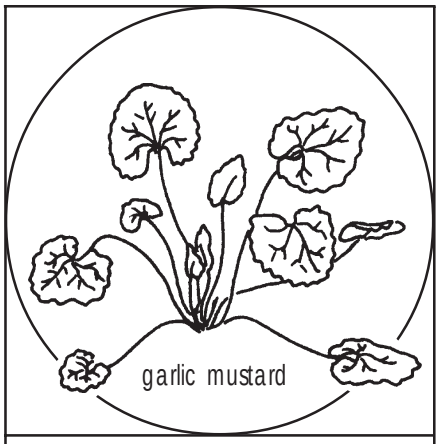
A Can of Worms



Method

Students will pour a mustard solution on the ground and watch the worms crawl to the surface! Then they will capture, sort, and count the worms. They'll be amazed at the beneficial *and* detrimental affects of worms on plant communities.

Getting Ready

1. Locate an area where you can conduct the investigation. Be sure you obtain permission to access the property and disturb the ground layer for sampling.
2. Follow directions in the middle of page 69 to mix the mustard solution at least four hours prior to the field trip.
3. Gather and/or check all materials.
4. Divide students into groups based on available equipment.

Introduction

Have you ever opened a can of worms? There are two ways to look at that question. You can look at it literally, as in, "Have you ever gone fishing and opened a can of worms so that you can bait your hook and catch a fish?" Or, you can look at it metaphorically, as in, "Have you ever found a complicated unexpected problem which cannot be resolved?"

It turns out that if you "open a can of worms" to go fishing, and then dump your leftover worms on the ground, you've opened a whole new can of worms for the forest!

Doing the Activity

For students in grades 4 – 8 and adults.

Plan to do this activity with small groups of three to seven students. Begin with a discussion about the importance of worms in gardens and crop fields. Use information presented in this lesson that is age appropriate. Follow the lab procedure outlined on page 72. Watching and counting the worms as they rise from the ground is dramatic! It will inspire an interest in worms, leaf litter, soil ecology, native wildflowers, forest regeneration, and invasive plants. Ask elementary students to prepare a report that describes the affects of earthworms on the forest. Encourage them to use drawings, digital photos, charts, and words to show the differences between an area with earthworms and an area without earthworms.

Objectives

- Identify the changes that occur when earthworms invade a forest ecosystem.
- Extract, count, and identify the earthworms in a sample plot.

Grades

4 – adult

Group Size

Small groups

Activity Time

Three 50-minute periods

Setting

Forest – This activity is best done in spring when wildflowers are visible, soil moisture is high, and soil temperatures are cool.

Materials

- Diagrams of forest floor without and with earthworms (page 71)
- Ground mustard powder (available in spice section of grocery stores)
- Empty gallon milk jugs with lids
- Water
- Rulers
- Tent stakes
- String
- Tweezers
- Ziplock bags
- Copies of lab procedure, data recording, and questions (page 72 – 74)

Connections

See next page.

Academic Standards

Grade 4
- Environmental Education: B.4.4
- Science: A.4.5, C.4.4, C.4.5, F.4.2, F.4.4

Grades 5 – 8
- Environmental Education: B.8.8, B.8.21, C.8.2
- Science: A.8.6, F.8.8, F.8.9

Grades 9 – 12
- Environmental Education: B.12.3, B.12.6
- Science: F.12.7, F.12.8, F.12.9

Scout Connections
- Boy Scouts: Environmental Science
- Webelos Scouts: Naturalist
- Junior Girl Scouts: Earth Connections

For students in grades 9 – 12.
Day One – Introduction

1. **Talk about worms**. Ask students to share positive and negative experiences with worms.

2. **List the benefits of worms.** Most people probably consider worms to be good. What are some of the positive things that worms do?
   - Aerate the soil.
   - Improve water infiltration and increase the water holding capacity of the soil.
   - Mix layers (taking organic matter into mineral soil and bringing minerals to the surface).
   - Break down dead plant and animal material and release the nutrients.
   - Provide an important source of protein to other animals.
   - Offer anglers cheap bait for catching fish.

3. **Discuss the effect of the Ice Age on worm populations.** About 10,000 years ago, the last glaciers covered much of North America to a depth of approximately one mile. What do you think happened to worms during the Ice Age? (If there were worms, they died. When the ice receded, there just weren't any worms or other soil creatures left. Animals and plants slowly returned to the glaciated areas.) Did worms return? (Yes, but worms aren't the fastest creatures! Without help, they can only move about 30 feet a year! At that rate, they could travel a little over half a mile in 100 years.)

4. **Discuss decomposers active in northern forests.** Decomposers are essential in a forested area. Without decomposition, leaves, twigs, and other organic matter would continue to accumulate and nutrients would be trapped. Fungi and bacteria are the active decomposers in forested areas. They work slowly, and, as a result, a thick, spongy layer of leaves and other plant material is always present on the forest floor. Look at the *Wormless Woods* diagram on page 71.

5. **Consider how earthworms invaded northern forests.** Since our native worms are still working their way north after the last Ice Age, how did all the worms that are in our soil get here?
   - Imported soil – Hundreds of years ago, the first settlers brought plants to America. Worms and worm egg cases were in the soil. This method of new infestations continues today as plants and soil are moved by landscapers and gardeners.
   - Ballast soil – Before people used water as ballast in ships, they used soil. The ballast probably contained

worms, worm egg cases, seeds, roots, and other soil inhabitants.

- Fishing bait – Some anglers purchase worms for bait and then discard the leftover bait on the ground. The fact that invasions often radiate from lake shores, fishing resorts, and boat landings confirms this practice.
- Soil amendments – Gardeners often add earthworms to garden soil to improve its productivity.
- Compost kits – Composters sometimes release worms purchased for composting into gardens or croplands.

6. **Discuss the problems invasive worms cause.** As the worms radiate out from each introduction, they reproduce rapidly and take over! It turns out that these worms might just be too good at what they do! When they invade a forest, they attack the deep leaf litter and rapidly recycle it. Look at the *Wormy Woods* diagram on page 71. Discuss how rapid recycling of the leaf litter changes the woods.

Day Two – Investigation

Preparation

At least four hours before the field trip, prepare the mustard solution. Prepare at least two gallons for a demonstration. For student lab, prepare two gallons for each team of four to six students. Mix 30 grams (approximately one ounce or 3 ½ tablespoons) of ground mustard with one gallon of water in a clean gallon milk jug. **Caution: Ground mustard can be an eye or skin irritant to some people. Prepare the mustard solution in a well-ventilated area and wear gloves to protect the skin.**

Lab

Follow *Lab Procedure* on page 72.

Day Three – Data Analysis

See *Data Recording and Analysis* on pages 73 – 74.

Answers to select lab questions from page 74.

4. In forested areas, higher populations of earthworms result in reduced leaf litter. The deep-burrowing types of earthworms seem to be more damaging to soil ecology.

5. In forested areas, heavier infestations of earthworms usually result in fewer native plants (i.e., tree seedlings and woodland wildflowers) and more invasive plants. Sugar maple seedlings seem to be very sensitive to earthworm invasions.

6. Unfortunately, this type of disturbance favors the growth of invasive plant species.

8. Educate anglers, gardeners, composters, and other forest users.

9. Scientists haven't found a solution. Maybe one of your students will come up with the answer!

Assessing the Learning

Observe student participation in the demonstration or lab. Older students can write a lab report that demonstrates their understanding of the procedure and outcomes.

Extending the Learning

Identify the worms. Using keys available on the Internet, students can identify the earthworms. Keys can be found at Minnesota Worm Watch and Worm Watch Canada. <www.nrri.umn.edu/worms/key/keyhome.html> <www.naturewatch.ca/english/wormwatch/resources/guide/index.html>

Play a game. With a roll of the die, students can simulate the movement of nutrients in a forest ecosystem both before and after earthworms invade. Game instructions and game tiles for *Invasion of the Exotic Worm* can be found on the Minnesota Worm Watch website. <www.nrri.umn.edu/worms/activities.html>

Set up an indoor worm bin. By monitoring a worm bin, your students can see how much plant material worms can eat through. It will be easy to see how a large population can change the forest floor in a short amount of time. You'll find the directions for setting up a classroom worm bin at Cornell University's Web site. <http://compost.css.cornell.edu/worms/wormhome.html>

Discover how nature did it first! Hot mustard solution is a relatively new way of getting worms to come out of the ground. While scientists used to rely on formalin (a powerful chemical), other worm-seekers used electrical shocks or waited for a heavy rain. However, the most amazing way to get earthworms out of the ground is probably grunting and fiddling them out! After pounding a stake into the ground, the "grunter" taps and rubs the stake with a metal bar to create a vibration that aparently drives the worms crazy! Within minutes, there are worms crawling all around the post! How did people discover this? They might have learned the technique from wood turtles. It seems that wood turtles stomp their front feet and munch on worms as they scramble to the surface. Anyone game for gruntin' worms?

Finding Out More!

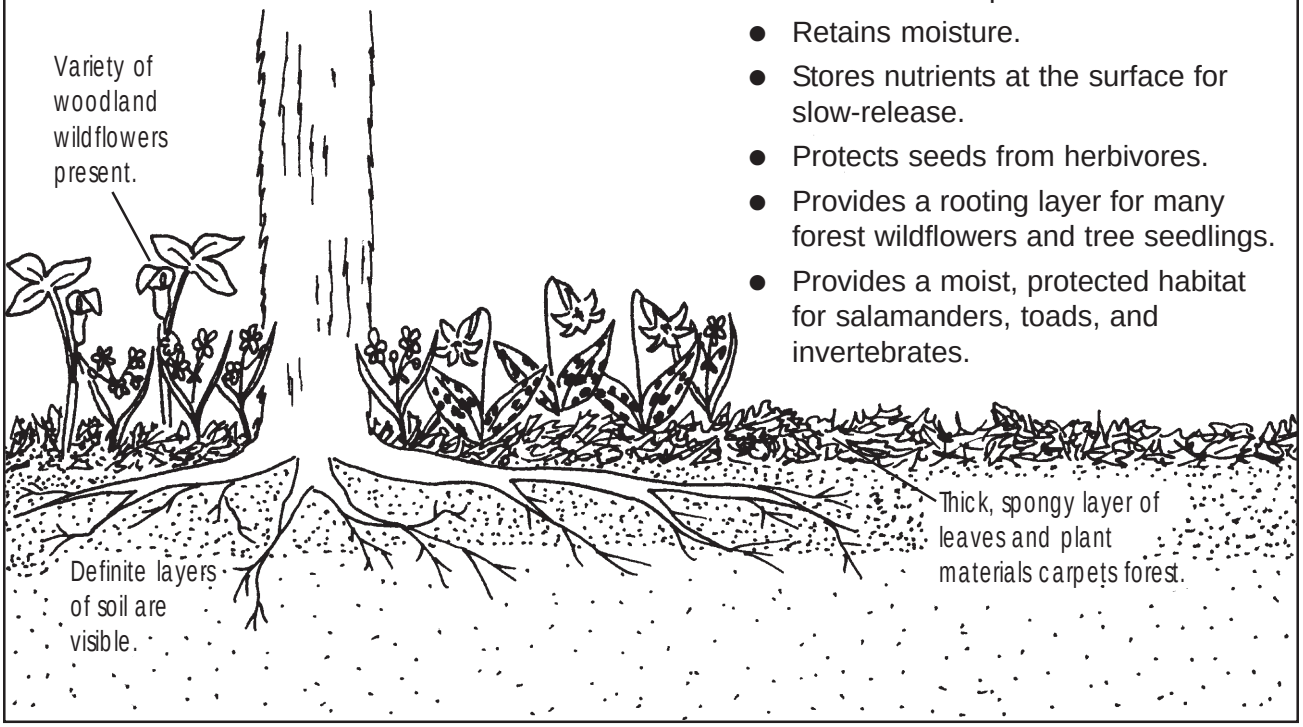
Minnesota Worm Watch. University of Minnesota. 2005. Online earthworm key, learning activities, and monitoring information. <www.nrri.umn.edu/worms/>

Worm Watch Canada. NatureWatch. 2005. Online earthworm key with photos of worms, the Virtual Worm Tour, and information about Canada's National Earthworm Survey. <www.naturewatch.ca/english/wormwatch/>

Wormless Woods

Leaf litter . . .

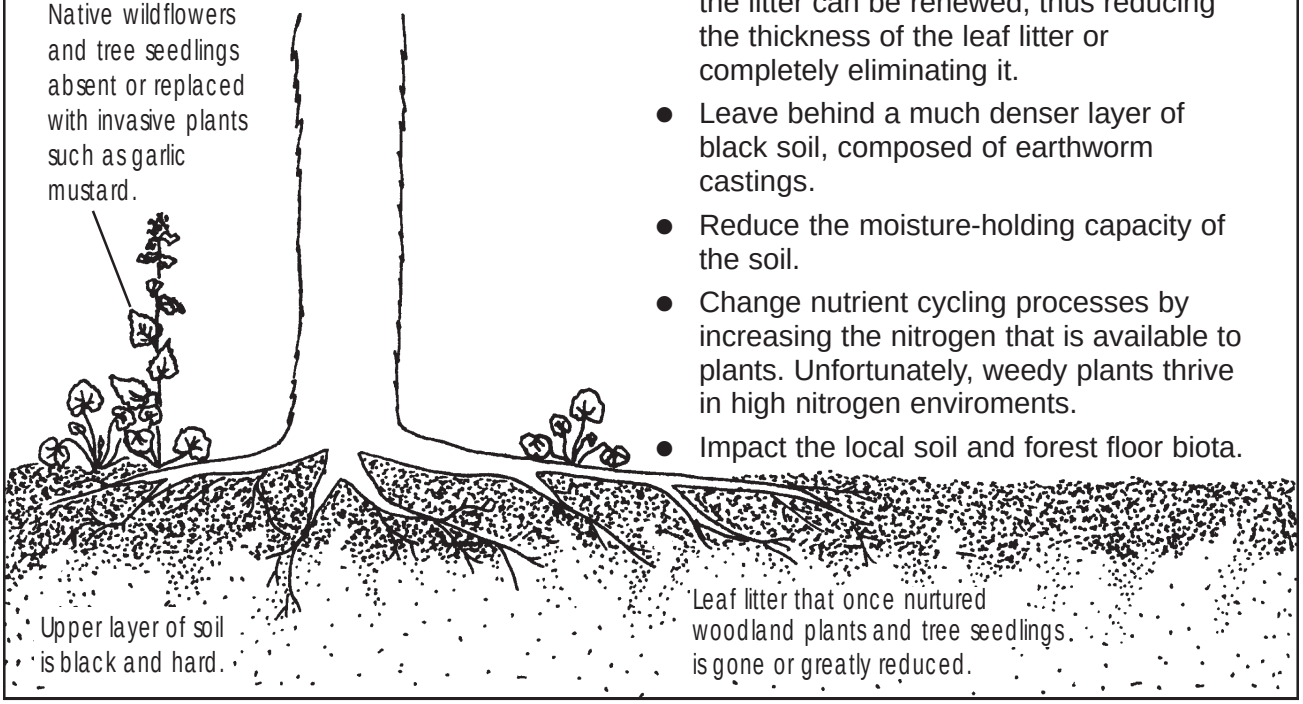
- Holds the soil and prevents erosion.
- Moderates temperature extremes.
- Retains moisture.
- Stores nutrients at the surface for slow-release.
- Protects seeds from herbivores.
- Provides a rooting layer for many forest wildflowers and tree seedlings.
- Provides a moist, protected habitat for salamanders, toads, and invertebrates.



Wormy Woods

Earthworms recycle leaf litter so fast that they . . .

- "Eat" through the plant litter faster than the litter can be renewed, thus reducing the thickness of the leaf litter or completely eliminating it.
- Leave behind a much denser layer of black soil, composed of earthworm castings.
- Reduce the moisture-holding capacity of the soil.
- Change nutrient cycling processes by increasing the nitrogen that is available to plants. Unfortunately, weedy plants thrive in high nitrogen enviroments.
- Impact the local soil and forest floor biota.



Lab Procedure

1. **Choose two forested locations to investigate.** One location should have native wildflowers and a thick layer of leaf litter. The second location should have greatly reduced leaf litter or bare ground. If possible, do the investigation in an area with sugar maples.
2. **Use the tent pegs and string to mark off a sample area that is one square foot in size.**
3. **Use a ruler to measure the depth of the leaf litter inside the sample area.** Record.
4. **Count the number of native, non-native, and invasive plants present in a three foot radius from the center of the sample area.** Make note of tree seedlings, saplings, and trees. In a forest with sugar maples, note if there are sugar maple seedlings. **Optional:** If approved by your teacher, collect and press plant specimens for later identification.
5. **Clear away the surface litter from within the sample site.** Don't forget to watch for and collect worms that live in the leaf litter! **Note**: Some may be small.
6. **Optional:** Use sticks, rocks, and dirt to make a small dike around the sample area. Follow your teacher's directions based on permission to disturb the site.
7. **Stir/shake the mustard solution and slowly pour one-half gallon of the solution onto the soil inside your sample area.** Pour slowly enough to allow all of the solution to soak into the soil and not run off.
8. **Watch for worms!** The mustard solution doesn't harm the worms, but it does irritate them. If present, they will probably begin to appear within one to two minutes. Use tweezers to collect the worms. Rinse the mustard solution off their bodies with clean water and transfer them to your plastic bag. Collect only the worms that emerge from within the sample area. Wait until each worm completely emerges or is nearly finished emerging before picking it up with the tweezers. If you try to pick it up while it is still in its burrow, you will probably only get half of a worm or it will retreat into its hole!
9. **After worms stop emerging or within five minutes, pour half of the liquid remaining in your gallon container (one-fourth gallon) onto the soil in the sample area.** Collect worms as they emerge.
10. **After five more minutes, pour on the remaining liquid (one-fourth gallon).** Wait at least five minutes after the last pouring to be sure that all worms have emerged.
11. **Complete the data recording sheet.** After you are finished with the worms, release them in an area adjacent to the test plot. **Optional:** Take the worms back to school to identify them.
12. **Repeat steps 2 through 11 at the second sample site with the other gallon of hot mustard solution.**

Can of Worms

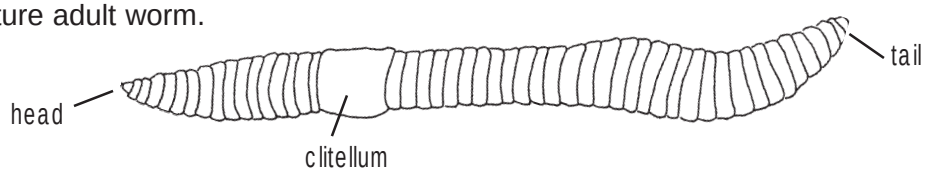
noun [originally U.S.]: a situation or specific problem which threatens to cause trouble and have irresolvable complications for all concerned; a complicated unexpected problem or unsolvable dilemma. The metaphor alludes to a product which might pass for acceptable before it is opened. However, once opened, it reveals a wriggling tangle of intertwined worms. The can of worms would normally be used for angler's bait.

Data Recording and Analysis

Record information for each location tested. Fill in the first two rows with information from your sites. Obtain data from other teams to complete the rest of the chart.

Location	Thickness of leaf litter in inches	Number of native plants	Number of non-native plants	Number of invasive plants	Number of earthworms

Sort the earthworms by age and type for each location. See the *Ecological Types of Earthworms* chart (page 74) for information on separating earthworms into groups. To determine if an earthworm is a juvenile or adult, look for the clitellum. If the clitellum is present, the worm is a sexually-mature adult worm.



Location	Epigeic		Endogeic		Anecic		Total earthworms per square foot
	Juvenile	Adult	Juvenile	Adult	Juvenile	Adult	

Lab Questions

1. Which location had the highest number of earthworms?
2. Which location had the highest diversity of earthworms?
3. A square yard of cropland can contain 50-300 earthworms. A similar area of grassland or temperate woodlands can have 100-500 earthworms. How do your numbers compare with these? Be sure you compare equivalent areas!
4. Is there any correlation between the number of earthworms and the thickness of the leaf litter? Is there any correlation between the types of earthworms and the leaf litter?
5. Is there any relationship between the number of native plants (wildflowers and tree seedlings), non-native plants, invasive plants, and earthworms?
6. When earthworms invade, several wildflower species are known to decline. If the native vegetation is disturbed, what will grow in its place?
7. Whether earthworms are considered “good” or “bad” probably depends on who you ask. What kind of response would you expect from a gardener? A robin? A forest wildflower? An angler? An ecologist?
8. What do you think is the best way to prevent further invasions into worm-free forests?
9. Once earthworms invade a forest, is there any way to stop their spread? Try to come up with a solution that removes invasive earthworms without affecting other soil creatures.
10. Some scientists are very concerned about the future of northern woodlands. Invasive earthworms and invasive plants are serious threats. When those threats are combined with growing deer populations, the results can be devastating. Why do you think scientists are so worried about the combination of these threats?

Ecological Types of Earthworms

There are three ecological types of earthworms. When using hot mustard solution, the surface-dwelling earthworms will typically emerge first, followed by soil-dwelling, and, finally, deep-burrowing species. Since soil conditions may prevent the mustard from reaching deep-burrowing species, extraction with mustard liquid is more effective for surface-dwelling species. Table adapted from **Teaching Organic Farming & Gardening: Resources for Instructors.** *Unit 2.3 Soil Biology and Ecology*. Center for Agroecology and Sustainable Food Systems. 2003.

Ecological type	Description	Habitat	Meaning of name	Examples
Epigeic – litter-dwelling species	Small (less than 3" long); dark red or reddish brown; move quickly	Live above the mineral soil; feed on organic matter	Epi= on Gaia = earth	Red wigglers *Dendrobaena octeadra* *Lumbricus rubellus*
Endogeic – soil-dwelling species	Small to medium (3" – 5" long); light gray or no pigmentation; slower moving	Live in the upper layers of the soil; feed on buried organic matter, mineral soil, and decaying roots	Endo = within Gaia = earth	*Aporrectodea sp.Octolasion tyrteum*
Anecic – deep-burrowing species	Large and muscular (5" – 8" long); reddish brown with wedge-shaped tail; more color on front end, less on tail end	Live deeply in the soil; feed on surface litter by pulling organic matter into burrow; can rapidly change soil ecology	Unknown	Night crawlers *Luymbricus terrestris*