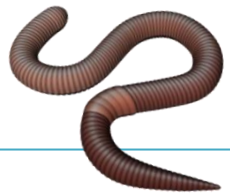
A FOCUS ON FOREST HEALTH: WISCONSIN WORM WATCH



Modified for Elementary and Middle School Students

Nutshell:
In this lesson, students will use language arts, science, and math skills to participate in a citizen science project and determine if invasive earthworms are present in a forest.

Background
Earthworms are newcomers to Wisconsin's forests. All native worms, if we had any, were killed during the last glacial period that ended 11,000 years ago. Humans have since introduced about 20 species of earthworms to Wisconsin from Europe and Asia by accident or for farming or fishing. All earthworms in Wisconsin are invasive species! Any native worms remaining after the glaciers have been outcompeted by invasive worms which spread much faster. Although worms can be good for your garden, they are bad for hardwood forests which evolved without earthworms disturbing the soil. See the attached "Earthworms and Earthworms-Invasive Species" handout for more detailed information.

Importance to Citizen Science:
The data collected through the Wisconsin Worm Watch survey is very valuable to Forest Health Specialists in the WDNR. Information provided in the surveys helps them understand the distribution of invasive earthworms across Wisconsin and their impact on local forests.

Objectives
Students will be able to….

- Participate in a citizen science research project
- Use scientific inquiry skills to conduct research on invasive earthworm populations in a forest
- Collect, measure, and record the number of earthworms detected
- Submit data to Wisconsin Worm Watch. A research project hosted through the Wisconsin DNR

WI State, National CORE, and Next Generation Standards:
Next Generation Science: HS-LS2-3,6,7 and disciplinary core ideas HS-LS2.B,C; MS-LS4.4 and disciplinary core ideas MS-LS4.C; MS-LS2-1.3.4.5 and disciplinary core ideas MS-LS2-A, B, C; 5-LS2-1 and disciplinary core ideas 5-LS-2.B; 4-LS1-1; 3-LS4-3
Math Core: MP.4; 7.SP.1,2; S.IC; S.MD; S-ID.1;HSF-IF.C.7; 6.RP.A.3; 6.SP.B.5; 6.SP.4; HS-modeling; S-IC.3; S-IC.6
English/Language Arts Core: RST.6-8.3; RST.6-8.7; RST.9-10.3; RST.11-12.3; WHST.6-8.1; WSHT.6-8.2; WSHT6-8.9

Lesson/Activity Time

- Pre-lesson: 30-45 minutes
- Lab Prep time: 10 minutes (Mix a 1/3 cup of mustard powder in 1 gallon of water & shake well)
- Lab: 30-45 minutes

Materials List

- Mustard powder (available at grocery stores or online…or contact Bernadette Williams, WDNR to see if she has any available to send to you)
- Disposable plastic water jugs (1 gallon or larger)
- Nonfiction literature and identification materials listed within the lesson plan
- Forest Site
- Copies of Student Worksheets
- Graph paper
- Air and soil thermometer
- Ruler to measure duff layer (leaf litter) depth

ENGAGE

1. Discuss the concept of invasive species and earthworms as invasive species in the forest.
2. Read the book Aliens from Earth: When Animals and Plants Invade other Ecosystems by Mary Batten
   Read and discuss the poster *Invasive Earthworms in our Forests: Contain those Crawlers* from the University of Minnesota Natural Resources Research Institute.
3. Allow students to develop questions that they would like to answer regarding earthworm biology, earthworm habitat, and their role in nutrient cycling, earthworms as an invasive species, and how they affect forest health.
4. Give students time to research background information about earthworm life cycles, earthworm anatomy, nutrient cycling, and earthworm distribution within the soil.
   Text set for earthworm information includes:
   a. An Earthworm's Life by John Himmelman
   b. Wonderful Worms by Linda Glaser
   c. Diary of a Worm by Doreen Cronin
   d. Wiggling Worms at Work by Wendy Pfeffer
5. Using the information students learned about earthworms, take a trip to the forest site and allow student to use inquiry skills to determine where the worm sampling plots will be located.
6. Assign students to each plot (or plots) to ensure that sufficient data is collected for completion of the survey worksheets.

Wisconsin Worm Watch Procedure

EXPLORE

1. Make sure students clearly understand the directions to conduct their investigations by using the *Wisconsin Worm Watch Survey.*
2. Travel to the forest site.
3. Conduct Earthworm Investigations by completing the *Wisconsin Worm Watch Survey.* ***All further procedural directions are listed within the Wisconsin Worm Watch Survey.***

EXPLAIN

4. Students should analyze their data and use critical thinking skills to answer the data analysis and conclusion section of *A Focus on Forest Heath: Data Analysis and Conclusions* worksheet.

EXTEND

- Send your students' citizen science results to the Wisconsin DNR.
  Contact: Bernadette Williams, Invasive Plants and Earthworms Outreach Specialist
  101 S. Webster St., PO Box 7921, Madison, WI 53707-7921
  Phone: 608-266-0624 or Bernadette.Williams@wisconsin.gov
- Conduct research projects on other invasive species found in the forest which affect the health of the forest.
- Create your district's own earthworm field guide. Identify and photograph each species of earthworm found in the sample plots, research and record information about each species, bind it together in a booklet.
  Nonfiction Text Resources include:
  a. Jumping Worm Field Guide cards and *Unwanted: Jumping Worms brochure* from the WI DNR
  b. Earthworms of the Great Lakes by Cindy Hale

EVALUATE

- Allow students to compare the number of worms and worm species they found by creating a graph with class data.
- Compare class data in different parts of the forest. Were certain sections of the forest more heavily infested with earthworms? Create a color-coded map that shows earthworm distribution throughout the forest
- Create an educational presentation that informs other students or the general public about the invasive nature of earthworms, why they are an ecological, economic, and social threat to Wisconsin's forests, and how to help prevent the spread of earthworms in Wisconsin.

Wisconsin Worm Watch Survey

Date of Survey ___/___/_____

School: _____

Land Type: Public Private Commercial Tribal

Location: _____

Are there any distinctive landmarks? _____

_____

Weather Conditions: Sunny Cloudy Rainy Slightly Overcast

Air Temperature: ____° Soil Temperature ____°

Is there a duff layer (leaf litter)? Yes No Measure depth? _____

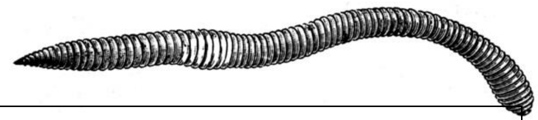
Mustard Extraction Instructions:

1. Select a site for Plot 1 and clear away any leaves or ground covering.
2. Get a bottle of the mustard water mixture from your teacher.
3. Pour half of the mustard water over cleared area. Count & sort worms that emerge for 5 minutes. Record the number of worms collected after 5 minutes.
4. Make sure all the worms are gathered then pour the other half of the mustard mixture in the same area and wait an additional 5 minutes. Record the additional number of earthworms that came to the surface.
5. Add the two numbers together and enter the total number of earthworms you collected for that plot on the data sheet.
6. After gathering all supplies keep the worms and move on to a new location 10 to 20 feet away and repeat the same procedure in your new plot. Your teacher will tell you how many total plots to do.
7. Throw away all earthworms you have collected. We don't want to re-infest the forest!
8. Complete the *Data Analysis and Conclusions* worksheet.

Submit findings to: Bernie Williams
Email: bernadette.williams@wisconsin.gov
Mailing Address: 101 S. Webster St., P.O. Box 7921,
Madison, WI 53707-7921
Phone: 608-266-0624

Name: _____ Date: _____

Record your earthworm data here:



Plot # ______

Number of earthworms counted after 5 minutes:_____________

Number of additional earthworms counted after adding the other ½ of mustard water and waiting another 5 minutes: _______________

Total Number of earthworms for this plot: _____________

Plot # ______

Number of earthworms counted after 5 minutes:_____________

Number of additional earthworms counted after adding the other ½ of mustard water and waiting another 5 minutes: _______________

Total Number of earthworms for this plot: _____________

Plot # ______

Number of earthworms counted after 5 minutes:_____________

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Total Number of earthworms for this plot: _____________

Plot # ______

Number of earthworms counted after 5 minutes:_____________

Number of additional earthworms counted after adding the other ½ of mustard water and waiting another 5 minutes: _______________

Total Number of earthworms for this plot: _____________

Name: _____ Date: _____

A Focus on Forest Health: Wisconsin Worm Watch

Data Analysis and Conclusions

1. Create a graph on the paper provided by your teacher. Plot the total number of earthworms found in each of your sample plots.

Use the graph you created and critical thinking skills to analyze the data and answer the following question.

2. Would you consider the total amount of earthworms found in your sample plots to be quantified at a low, medium, or high level?

a. Why did you choose this infestation level? What did you compare it to?

Use the background information you know about earthworms, the data you collected, and good critical thinking skills to answer the following questions about the impact earthworms may be having on your forest site.

3. Think about the role the earthworms play in the energy flow or nutrient cycling of your forest's ecosystem. Diagram a food web or show the cycle in which nutrients may flow throughout the forest's ecosystem. Be sure to include the earthworm's role in your diagram! (Put your diagram on the back side of this paper.)

4. How does the invasive earthworm population affect the health of the forest?

a. Describe your forest habitat. What types or species of trees and vegetation are present?

b. Which species of trees or ground vegetation might be present on your forest if these invasive earthworms were not altering the cover type?

Background information for teachers….

Earthworms

Background

Earthworms are newcomers to Wisconsin's forests. All native worms, if we had any, were killed during the last glacial period that ended 11,000 years ago. Humans have since introduced about 20 species of earthworms to Wisconsin from Europe and Asia by accident or for farming or fishing. All earthworms in Wisconsin are invasive species! Any native worms remaining after the glaciers have been outcompeted by invasives which spread much faster. Although worms can be good for your garden, they are bad for hardwood forests which evolved without earthworms disturbing the soil.

Description

Worm anatomy and a photo of an endogeic earthworm, the leaf worm.

Wisconsin has 3 types of worms:

- Surface dwelling (Epigeic) worms, such as composting worms, form no permanent burrows and live near the soil surface
- Topsoil dwelling (Endogeic) worms, such as the leaf worm, build horizontal burrows deeper in the soil.
- Soil dwelling (Anecic) worms, such as the Common Nightcrawler, build semi-permanent, vertical burrows that go down into the soil from the surface.

Signs and Symptoms

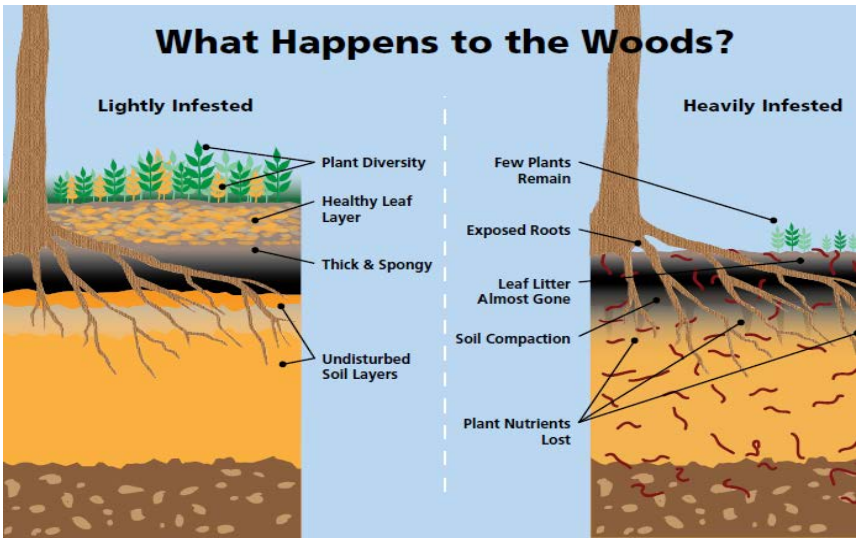
- Earthworms
- Middens - piles of cast material (earthworm poop) around the openings to their burrows
- Burrows with partially eaten leaves or stems sticking out
- Forest with bare soil – no or little leaf litter on the forest floor
- Invasive plants – Invasive plants take advantage of earthworm disturbed soil

Earthworm middens with the stems of eaten leaves sticking out and piles of castings around the burrows. Notice the lack of leaf litter surrounding the middens.

Habitat and Current Distribution

Invasive earthworms are found in hardwood forests all around the state but earthworm free areas still exist. Surveys are being conducted to determine the species of worms present in Wisconsin and the distribution of each species.

Impact and Management



Earthworms are a major threat to Wisconsin's forests.

- Ecological – When earthworms burrow and mix leaf litter and the soil, it is a major disturbance for Wisconsin forests. Healthy forests that evolved without earthworms depend upon fungi and invertebrates to slowly break down organic matter and gradually release nutrients back to the plants. Earthworms disrupt this normal breakdown of leaves. This is important because the leaf litter in a forest is comparable to the skin on an animal. The leaf litter retains moisture, protects the organs (roots), breathes, prevents erosion, deters pathogens (non-native plants), and promotes seed germination. Worms puncture the "skin" by eating leaf litter rapidly which exposes the soil, making it available to invasive plants, compaction, and run-off of rainwater, which would normally keep the soil moist. The disturbance also reduces the diversity of plants, insects and other species.
- Economic – Healthy forests are critical to Wisconsin's economy. Forests with earthworms have few regenerating seedlings and often instead have invasive plants. This means that if a group of trees dies or is cut, there are no trees to replace them. Healthy stands have abundant seedlings and few costs, while sites with earthworms cost much more because foresters or landowners must pay to treat the invasive plants and establish seedlings.
- Social/recreational – Earthworms can be a benefit to humans when kept contained in composting piles, agriculture fields and gardens. But the same benefits they provide in human controlled landscapes have major costs in natural ecosystems. Keeping worms out of our forests will help keep them healthy for all of us to enjoy.

While we don't have a way of ridding the forests of worms once they are established, we can keep them from spreading to forests that are not yet invaded. You can help prevent invasive worms from spreading in Wisconsin by:

- Invasive worms enter the forest primarily through horticulture, agriculture, and recreation.
    - If you fish DO NOT dump your worms in the water, on the ground, or in the woods. Dispose of live worms in the trash.
    - If you plant trees and shrubs on your property examine the root balls for worms and destroy any you find.
- Wash your shoes and tire treads when you leave a site with earthworms so you do not spread them to the next forest you visit.

For more information

- http://dnr.wi.gov/topic/Invasives/
- http://www.nrri.umn.edu/worms/default.htm

Created by Mike Hillstrom, WDNR Forest Health Specialist

Invasive Species: Will the introduction of a nonnative species cause, or is be likely to cause, economic or environmental harm or harm to human health?

It's important to understand the relationship earthworms have with the soil and that this relationship is not always beneficial, even though this can be a difficult topic. Given that common understanding has been that worms are beneficial for growing plants.

In the glaciated regions of North America our understanding of the presence of earthworms is established through the glacial and post-glacial geological and ecological records. Those records establish that the regeneration of our native plant species developed in the absence of earthworms. Furthermore we know that all of our most pervasive and ubiquitous earthworms are native to Europe. This helps us to establish the basis for our understanding that when the first explorers arrived in these formerly glaciated regions, they also brought along earthworms that many people today assume were already here. Additionally, when you examine the record of the native forests and vegetation of Wisconsin prior to the arrival of European settlers and the cutover that scoured the land of our native hardwoods, you're struck by the amount of diversity and density of those forests and vegetation. The westward expansion and the continued arrival of new settlers to these lands transformed them from native forests to prairies to wide rolling expanses of agricultural lands and dairy farms, which have altered the appearance of the landscape, and provided mechanism for a wide variety of non-native species to spread across the landscape.

Earthworms – Invasive Species

Objective:

Students will learn what invasive species are, how they got here and why they are problematic, and how to prevent their spread by using earthworms as the primary example.

Background

A **native species** is a plant or animal that occurs naturally in a certain area. Because it evolved in that area over time, it typically co-evolved with other species that served to keep its population in check through predation, competition, or disease.

Invasive species (non-native species) are species that have been introduced or moved by human activities to an area where they do not naturally occur. A non-native species is not necessarily harmful and in fact, some non-native species are beneficial (e.g., honeybees). However, when a non-native species overruns or outcompetes a native species in natural communities or ecosystems it can cause ecological, environmental and economic harm and is frequently labeled as an **invasive species**.

When **invasive species** enter new locations and do not have any natural controls that would serve to limit their spread and population they typically spread at a high rate outcompeting the native species. Because of the lack of natural predators, high reproduction rates and the ability to adapt and tolerate a vast array of conditions it enables them to take over in non-native areas.

Invasive species are not just a problem in Wisconsin but they are a problem worldwide as they degrade and change habitats, crowd out native species, and prevent our native forests from regenerating. Once established invasive species are nearly impossible to remove and controlling and limiting their spread is time consuming and expensive.

Invasive species are not a new phenomenon, with globalization and increased world-wide travel and shipments of goods new introductions are occurring continuously. Scientists estimate that in the United States alone we have over **7000 established invasive species** ranging from plants, mammals, birds, amphibians, reptiles, fish, arthropods, and mollusks.

There are many ways in which **invasive species** end up in new locations and commonly it's because we intentionally introduce them or we accidentally introduce them thinking they are good for the environment not realizing the damage they may ultimately cause. For example earthworms, we've all been told that earthworms

are good for the soil and help things grow. Though in Wisconsin our native earthworms were destroyed during the last ice age, roughly 10 thousand years ago when the glaciers retreated our native plant species grew and evolved without the presence of earthworms in the soil.

The question than is how did they get here? We introduced them of course! Here's the tricky part - we introduced ourselves as well. Just like new introductions of plants and insects that occur constantly at our boarders, we were the first "invasive species" to make our way into North America and because of our ability to travel and move long distances and adapt to new environments we grew and spread except that we also brought along more non-native species with us because as we made our home in the new world we wanted to have things that reminded us of home.

So how does this explain earthworms? Before settlers arrived in Wisconsin it was a vast wilderness of dark dense forests which would have been for the most part undisturbed, uncharted territory aside from Native American's whose home it was. With the arrival of European settlers also came the arrival of non-native plants and the soil that held them, which created a mechanism for introduction. Earthworms live and reproduce in soil, and while they didn't realize it, soils contain earthworm cocoons (eggs).

When European settlers expanded their range across North America they took advantage of the resources which, in Wisconsin, was the vast forested lands which provided timber for building and shelter as well as fuel and heat. It wasn't long before the expansion and cut-over of Wisconsin's forests was rapidly progressing, and the soil disturbance of logging practices and settlement of towns and homesteads changed the soil and native **ecosystems**.

While the presence of earthworms in our forests may not seem like much to be concerned about, we need to remember that, just like a healthy diet and proper nutrition is key to our growth and development, the soil on the forest floor is just as important to the health of our trees and how they grow. Earthworms affect how the soil works, and so it is important to know how that interaction takes place, and what it does.

Earthworms are **nature's recyclers** and they are incredibly efficient at the job they do – sometimes too good! While they are extremely beneficial and good at consuming kitchen scrapes and **fertilizing** our gardens, this same benefit has the exact opposite effect on our forests.

Imagine yourself walking through the woods on a crisp autumn day the leaves are vibrant in color and many have fallen from the trees and they're covering the forest floor in an array of beautiful colors. Imagine that carpet of leaves almost as a protective skin blanketing the forest floor and protecting it from the cold winter months that lie ahead. That protective layer over the forest floor is essential to the regeneration and growth of our native trees. The problem is that there is something eating them, and that "something" is earthworms.

If an earthworm could speak it would tell you that its favorite foods are freshly fallen leaves, and in particular, the leaf of a Sugar Maple (Acer saccharum – the Wisconsin state tree!). When earthworms consume fallen leaves, they interrupt an essential cycle that occurs between the soil and the micro-nursery created by the fallen leaves. For example if you were to pick up a pile of fallen leaves after they've built up you may notice something that looks a little like white mold, but what you're really seeing is **mycelium** which is a naturally occurring **fungus** that has an integral and **mutualistic relationship** with the regeneration of most of our native species. When earthworms consume the fallen leaves, they disrupt the relation between the soil and the **fungal layer** that is not only protecting the soil but also feeding and encouraging the process of regeneration on the forest floor. A forest with earthworms is a forest that experiencing a change in how things grow and what will grow.

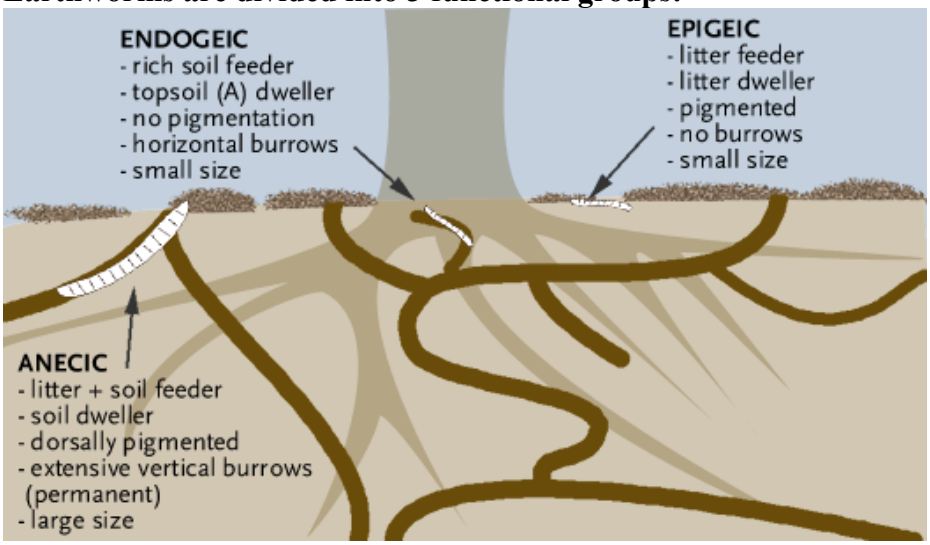
What can we do? In Wisconsin we still have areas of the state that are earthworm free as well as areas that have **minimal** spread and **abundance** of earthworms. If we can document these areas early on before infestations occur, and educate and change the **perception** of what earthworms do and why they are harmful to the health of

our forest, we have a good chance of **minimizing** their spread. Additionally, minimizing the spread of earthworms helps to reduce the spread of a host of other invasive species i.e., garlic mustard, honeysuckle, buckthorn. This is because earthworms change the soil and the nursery effect that leaves have for growing trees, which leaves those "new ecosystems" open to some of the best opportunists out there – other invasive species, which are usually faster growing, more aggressive, and less palatable to native foragers, diseases and insects., Generally, when you have one invasive species you'll have another, and earthworms are no exception!

What you need to know

- All earthworms in Wisconsin are non-native invasive species.
- Earthworms affect and alter the health of our forests.
- You can help document the presence of earthworms in Wisconsin

Earthworms are divided into 3 functional groups:



Three major ecological groups of earthworm have been identified based on the feeding and burrowing behaviors of the different species.

Vocabulary:

Native species	Nature's recyclers	Mutualistic relationship
Invasive species	Fertilizing	Minimal
Biodiversity	Fungus	Abundance
Regeneration	Fungal layer	Minimizing
Ecosystems	Mycelium	Perception