Worm Worlds

Activity Overview
In two different habitats, students raise earthworms to the soil surface by using a non-lethal irritant, then count and compare worm populations.

Objectives
Students will:

- Learn about worms in general
- How they effect the soil for good and bad

Subjects Covered
Science and Math

Grades
1 through 12

Activity Time
30-60 minutes for outdoor investigation and additional classroom analysis time

Season
Spring or Summer (not when soil is dry)

Materials
Gallon Jugs (for Mustard Slurry), Sprinkler Head for Slurry Jugs (allows for easy, even pouring), 2 T of Dry Mustard Powder per gallon jug (best from bulk organic grocers- must be fresh!), Measuring Spoons, Film Canisters (for measured mustard), Funnel, Nail/Thumbtack (for poking air hole into slurry jugs), Gallon Jugs of Water (for wetting and washing worms), 6" Bowl (for holding worms), Clippers/Scissors (for cutting grass to see worms better), Measuring Sticks , 5" Stakes/Pencils, Permanent Markers (two different colors), Pencil/Pen, Worksheets, Clipboard/Cardboard, Container for materials

State Standards
Science: F.4.1., F.4.2., F.8.1., F.8.2.

Math: A.4.1., A.8.1., D.4.1., D.8.1

Source
NAAEE – VINE Neighborhood Ecology Network

Background
Earthworms are those squirmy and sometimes slimy little animals, known as invertebrates with soft, squishy bodies you find in the dirt, on sidewalks and everywhere in between, especially after a rainstorm. They may seem too small to really make a difference, but everyday our lives are affected by these creatures. They nourish the soil for the plant life we and our livestock eat, as well as create rich nourishment for all the fauna we enjoy. No one really knows just how significant these tiny dirt-munchers are to life on this planet but we can all be sure whether we see the effects they have or not they are making a big difference everyday.

That difference starts with what earthworms do best; eating dirt. Worms can eat nearly their own weight in food in one day. In fact Darwin was the scientist to discover that earthworms turn the top six inches of topsoil over every twenty years based on his observations of Stonehenge sinking. Until he wrote his book about these wonderful worms many people considered them pests. Today they are revered by farmers and gardeners for their ability to fertilize and aerate the soil. Scientists estimate that a healthy worm population of 50-200 per square meter can move nearly 30 pounds of soil each year. Now that's a lot of mud pies!

In North America, earthworms eat dead or decomposing matter, such as leaves, sticks, dead insects or animals. When worms eat the food passes through the mouth opening to be ground up in the gizzard (the equivalent to a stomach) by grit and then nutrients are absorbed in the intestines. Worms prefer some leaves over others for different reasons. One reason is sweetness and lack of bitter tannins, and another is shape or size. They prefer to eat fresh leaves in the order of beech, maple, oak, horse chestnut, lime and willow. They prefer to eat decaying leaves in the order of willow, oak, lime, beech, maple and horse chestnut. At night when they are mostly active the worms anchor themselves in their burrows and then stretch up to fourteen inches to do a sweep outside the mouth of the burrow looking for food. People who rake leaves from the shady parts of their lawns take away a large food source for these little earth-dwellers, especially because winter is the time of the heaviest accumulation of ground debris. They need it to survive.

As much as we all see these rather interesting creatures, surprisingly earthworms and red wrigglers are not native, and are thought to be European and Asian immigrants. These worms have had extreme success in the northern areas and continue to cross North America. Due to recent studies done in Wisconsin, it is thought they are still migrating north at about 20 feet per year. Only in the past ten years have they ac-

tually started to reach Canada. Unfortunately, this has little to do with their fast paced dash north and more to do with how they hitch a ride in fishermen's bait cans.

It seems these worms are a mixed blessing because they do great wonders for incorporating all the organic matter that falls from trees into the soil, but this also means they can lay bare soil that easily erodes during storms. Some of their tunneling and aerating can prevent erosion by allowing water to more effectively seep into the soil, but in many places these worms are working too well. Without the earthworm the soil would be covered in enough organic matter to keep it from washing away.

Ten thousand years ago after the last Ice Age glaciers retreated they left a vast worm-free zone, which might have been taken over by later by a southern native species, which have been around for about 120 to 500 million years ago, but immigrant species beat them to it. In the north they seem to be crowding out native species because there are so equipped to thrive in recently disturbed soils while the native species is not. Native species may also be losing a large part of their habitat due to logging and other such practices. However, in the south the natives are doing better than the invaders because they are suited more for warm weather, while the immigrants go dormant in order to keep from drying out.

It is not certain what will happen if these immigrant species start to replace more of the native species. As less and less of the world's surface is left undisturbed this could end up meaning there are only a handful of species dominating the world's ecosystems. This creates less diversity all the way up the food chain and scientists are only beginning to understand the trickle down effects this may have. One effect may be that as these worms turn leaf litter into ammonium which the bacteria feeds on and turns into nitrates. These new forest floors may be favoring those plants that prefer nitrates (which are only a few specialized plants). Also these nitrates leach faster from the soil, which could starve forests but also clog up local waterways because the algae just love it. The over-growth of algae suffocates fish and other invertebrates who live in the waters. Big seeds from trees need this leaf litter to help hide them from predators, while small seeds from trees would normally rot in the leaf litter. This causes a selection for only certain types of trees to flourish. This means less oaks and more maples. There are also many small animals who need that leaf litter for shelter and food, like the salamander who is rapidly disappearing from the northern forests. These changes could be irreversible.

The problem with worms is not that they are in people's gardens or composts but that they are starting to invade virtually untouched northern forests. "'Worms change how nutrients are cycled and alter the structure of the soil,'" says Cindy Hale, a University of Minnesota biologist. She's been studying these earthworms since the nineties and she says, "They have a cascading effect on plants, animals, and soil organism, and we know they're causing significant damage to some forests. Their effect could be really profound.'" What is worse is how hard it is to convince people, even scientists, that this is important issue. Hale explains, "'We're taught in kindergarten that worms are good. But these are ecosystems that evolved since the last glaciation in absolute absence of worms.'" (insert source) This is very important because scientists are only beginning to understand the effects these worms are having and no one yet knows how to stop them once they reach a new area.

Fortunately, everyone and even you can do their part to slow their migration, such as trying not to fish with worms or if you must try not to throw the worms on the ground near where you are fishing, instead throw them away. You can freeze your compost first to kill any worms or their cocoons tp avoid releasing them into your garden. Keep an eye out for worms in rural areas and northern territories. Remember that anytime leaf litter, mulch or straw is moved it could be transporting worms, so do everything you can to avoid accidentally introducing them. Mud on thick tire treads can transport worms so wash the tires of your trucks and off-road vehicles before transporting them to another area. Just doing a little bit can keep our worms where we need them and out of the forests where we don't.

Activity Description

Teacher Portion:

1. This activity should be done with a group of about 6 to 60 students that are placed in smaller groups of 2-3 each. It will take about 10 minutes to introduce the activity, choose habitats to compare and explain the procedures. It will take students about 20-30 minutes to set up their quadrant and count the worms. After the class comes back together it will take another 30-45 minutes to collect class data, summarize, compare, interpret and discuss results. This whole activity can be done outside if teachers choose to.
2. Introduce the activity outdoors or indoors by giving students an idea of the different habitats earthworms can live in. Then have students pick two of the habitats near you to do your testing in (e.g. Lawns versus planted beds, playing fields versus ornamental lawns or plant beds with wood chips versus leaf mulch, bare soil in the open versus under shrubs, healthy grass versus trampled grass) and outline the boundaries of these test sites. Explain to students how the entire test site would be too large to do, so they will take a sample. Demonstrate how to create a quadrant and count the sample of worms.
3. Explain what and how the mustard slurry works, how to remove leaf litter or grass so the worms can be seen, how to wash the worms off to count them, how to tell which ones are juveniles (the one's without the fleshy clitellum band) and where to place the worms after they are done counting them. Briefly explain how to fill out the worksheets they will be taking with them outside.
4. Distribute materials.
5. Circulate among the students in order to observe for accuracy and help them if they have any questions. Things to look out for include crooked quadrants, pouring slurry too fast- it should all stay in the quadrant, injured worms (stress the importance of respecting this creature), worksheet completion and no worms (help them see that this an interesting result and ask them to explain it based on their procedures or the habitat).
6. Combine the groups results after clean up and find a class average. Discuss results. Questions to ask during the discussion could be; is the prairie soil too dry, is the root mat too dense, does soil temperature affect abundance, is abundance related to soil moisture, are there more in forests or lawns, young or older prairies, what creatures take their place and are there any transplanted trees nearby?

Students Preparing for Test Site:
This will be done outside before students make their mustard slurry.

1. Students will need gallon jugs of just water, a bowl, string, four 5"stakes, measuring stick, and two permanent markers of different colors.
2. First fill the bowl with a tiny bit of water from the clean water jugs for washing the worms and set it to the side.
3. Next make a loop in the string (this step can be done inside beforehand) and begin to mark it using the measuring stick at 50cm, 100cm, 150cm and 200cm, and a different color mark at 171 cm. Also partially sharpen stakes with a pencil sharpened to make sure they go in the ground easier.
4. Outside have the student choose their own spot to test within one of the class chosen habitats. They can now begin to make their test quadrant by first sticking one stake firmly into the ground then placing the loop of string around it.
5. Next pull the string straight up until you reach the 50cm mark. This is where you place your next stake firmly into the ground. Make a right turn with the string and pull it out until you reach the 100cm mark.
6. Then bring the string across the diagonal between the 50cm stake and the 100cm stake, so that the 171cm mark meets with the 50cm stake. Pull it tight so that you know the finished product will have more accurate right angles and not be crooked. Place the third stake in at the 100cm mark.
7. Then move down pull the string straight until you reach the 150cm mark. Place the fourth stake here. Then have the end of the string meet the first stake, where you tie it to secure the quadrant.
8. Once you have your quadrant remove all loose debris from the inside. Next use the scissors to cut back any grass so that you can see the worms better and make it easier to grab a hold of them. After you have done all this you are set to go!

Students Making Mustard Slurry and Testing:
This will probably be done outside after students set up their quadrants because it must be done immediately before pouring.

1. Each group of students will need one gallon jug full to the very top of just water, one empty gallon jug, one film canister full of the measured 2 T of dry mustard powder (this step can be done inside or before by the teacher), a funnel, a sprinkler head, a nail/thumb tack (this is to poke a hole in the slurry jugs for air to escape and this can be done beforehand), and their worksheets, pencils and clipboard.
2. Use funnel to pour film canister of dry mustard powder into empty gallon jug. Then use the funnel to add about one gallon (any less water leads to higher concentrations and can hurt the worms) of clean water to the slurry jug. Cap the slurry jug and shake vigorously.
3. Attach sprinkler head to the slurry jug.
4. Begin pouring ALL of the mustard slurry slowly and evenly into the quadrant. This should take 2-5 minutes if students are making sure not to pour outside the quadrant.

5. Wait until worms are completely out of the ground before picking them up or else they will pull back into the ground and be impossible to count. Students can count worms that do not come out completely as long as they don't count them twice. After picking them up they should be placed in the bowl with water to wash them off and make them easier to count. It also helps prevent injury to the worms.
6. Have one person in charge of marking the worksheet with the total number of worms and the total number of juveniles.
7. After students count all the worms have one person put the worms back on the ground near but NOT in the quadrant, and out of direct sunlight to continue to avoid injurying the worms. The other students can be collecting their materials to go back inside for clean up and class data analysis.
8. Discuss how they might improve upon part of the testing site. What changes would they make to increase the number of worms? How would they test whether their actions worked?
9. Estimate total number of worms in one of the habitats chosen.
10. Measure dimensions of habitat and then calculate its area. Mmultiply the average number of worms per quadrant in that habitat by 4 to get the number of worms per square meter. Multiply habitat area by this number to get estimated numbers of worms in the entire area.

Extensions

- Start a worm farm and watch how much they effect their environment.
- Devise a plan to spread the word to the public about the good and bad effects worms can have on the environment.
- Put worms on clear surface, like Plexiglas, that is lightly spritzed with water to watch the worms and how they move. Also have the students shade half of the surface and see which direction the worm wriggles. Worms usually like moist, dark areas so that their skin won't dry out and they can breathe easier.
- Attach a string to a leaf inside one of your quadrants and watch how it moves over time. If students watch long enough, the leaf may start to disappear.
- Students can remove worms from the wild and put them into a classroom terrarium like environment for a short period of time. Cover the soil layers with leaves from local trees and track which ones the worms prefer to eat. Remember to return the worms to a cool, dry place away from predators.

Additional Resources

- Bergman, Lincoln, Hosoume, Kimi and Robert C. Knott. Earthworms, Teacher's Guide. Great Explorations in Math and Science (GEMS). Lawrence Hall of Science, Berkeley, CA.
- McLaughlin, Molly. (1986). Earthworms, Dirt and Rotten Leaves. Avon Books, New York, NY.

- Worm Digest. A quarterly publication of the Edible City Resource Center, box 544, or 97440.
- Other activities related to worms from Outdoor Biology Instructional strategies: Super Soil, Terrestrial Hi-lo Hunt, Litter critters, Bean bugs
- More info/ and other NAAEE programs and resource call 937-676-2514

Assessments

- Students can graph the class' averages showing the difference between the two habitats.