Root Community

Tallgrass Prairie Center

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ROOT COMMUNITY

BACKGROUND

Roots don’t just withdraw water and nutrients from the soil; they give back to the soil by providing food and habitat to a diverse community of soil microorganisms and invertebrate animals. Living roots release carbohydrate-rich substances, called exudates, which attract and feed root-zone bacteria. Roots also form symbiotic relationships with special fungi, exchanging carbohydrates for better access to soil nutrients. Tiny arthropods are the soil’s grazers, feeding on the root-zone bacteria and fungi. Herbivores eat living plant material, including roots. Shredders break down dead plant and animal matter, releasing nutrients into the soil. Predators feed on the grazers, herbivores and shredders. Omnivores consume a variety of materials, living or dead, plant or animal.

Taken together, the roots, microorganisms and soil animals (fauna) form a complex food web that performs important ecosystem services. Soil microorganisms, grazers and shredders are key players in nutrient cycles, aiding in the break-down and decomposition of organic materials. Root-zone microorganisms compete with disease organisms, and predators regulate the populations of pest species. All soil animals mix the soil and improve soil aeration and infiltration as they dig tunnels and move through the soil.

The types and activity of soil animals vary depending on factors including season, soil type, depth and vegetation type. The soil community is usually more abundant and diverse in soil around perennial root systems in grasslands or woodlands. Roots that persist from year to year provide a consistent source of food for soil bacteria and fungi, allowing organic matter to remain stable or build up over time. Perennial roots also help to build soil structure, pore spaces and channels, thereby providing homes and highways for soil fauna.

In this activity, we’ll test these generalizations by searching for soil invertebrates in soil samples with and without perennial roots.

Overview
Students will use hand lenses to search for and identify soil invertebrates in soil samples with and without perennial roots.

Objectives:
• Observe and identify diverse soil invertebrates from soil samples.
• Describe the roles of soil invertebrates within their food web.
• Compare the number and diversity of soil invertebrates from soil samples with and without prairie roots.

Subjects Covered:
Science

Grades: 7-8

Group size: Variable (dependent on availability of materials)

Activity Time: 45 or more

Season/Location:
Late spring through fall (best when soil is warm and moist)

Materials:
• Prairie root specimen (ideally), prairie root poster or image
• Soil samples with and without perennial roots
• Newspaper
• Black & white construction paper
• Hand lens
• Fine paint brushes
• Small, plastic plates or bowls
• Rubbing alcohol
• Buckets for used soil
• Identification guides (Appendix A)
• Data Sheets (Appendix B)

tallgrassprairiecenter.org
VOCABULARY

Community: The various kinds of living things that live and interact in an ecosystem.
Invertebrates: Animals without backbones such as worms, insects, snails and spiders.
Grazers: In soil, invertebrate animals that feed on the microorganisms around plant roots or on decaying organic material.
Herbivores: Animals that feed on living plant material, including roots.
Shredders: Soil animals that break down dead plant and animal material into smaller pieces.
Predators: Animals that feed on other animals.
Omnivores: Animals that consume a variety of food types.
Fauna: Animals.
Food web: A way of organizing living things by “who eats whom.”
Ecosystem services: Beneficial functions provided by diverse organisms interacting with each other and the environment in which they live.
Aeration: The movement of air into the soil.
Infiltration: The movement of water into the soil.
Perennial: Living for many years.
Organic matter: Component of the soil that comes from partly to fully decomposed plant and animal residues.

TEACHER PREPARATION

- Gather sets of materials for groups of 2-4 and place them at work stations. Cover each work area with newspaper. If working outside, you may need to use a different work surface (such as cardboard) and weight it down in case of wind.
- Locate two sites where students can sample soils with different amounts of roots OR bring in soil samples from two different sites. Try to keep the soil structure within each shovel-full intact.
- Provide labeled buckets for “used” soil from each site. Return soil and soil animals to the sites they came from.

ACTIVITY

Introduce the activity

1. If you have access to a prairie root specimen, gather your group around it. (If you do not have a specimen, project a poster or photo of prairie roots. See www.tallgrassprairiecenter.org/curriculum_images.) Have students make guesses as to how much of a prairie plant is below ground.

2. Remind students that above-ground prairie plant parts are food and shelter for things like grasshoppers, birds, mice and bison. What kinds of animals live and feed on and around the below-ground parts? How important are roots to the things that live in soil? We are going to find out!

3. Assess how much students already know about food webs and their basis in plants and photosynthesis. Ask them if animals could survive on earth without plants. If students respond that predators do not need plants, use follow-up questioning to get them to see that the ultimate source of food is always plants.

4. Extend the understanding of food webs to below-ground ecosystems. Ask them to make predictions about where they will find more soil animals – in soil with lots of roots or in soil with few to no roots.
Procedure

1. Provide soil samples or go outside as a class to collect them. Provide samples that vary distinctly in the number of roots present. Students will rate the amounts of roots in their samples using this scale: FEW (up to 10) or MANY (10s to 100s). Each group will examine one soil sample.

2. Hand out identification guides (Appendix A: Soil Fauna ID Cards) and data sheets (Appendix B). Explain how to use the identifying features on the ID cards and how to record tally marks on the data sheets. Ask students to think of things they might want to record in the observations column (size, color, how fast they move, reaction to light, found closer to or farther from roots, etc.).

3. Tell students that they will need to look carefully to find invertebrates that are very small, often pale in color, and tend to move away from light. Most of the animals in the soil will be even smaller than BABY earthworms. They may not look very impressive at first, but under magnification they may give you ideas for designing the next alien space-monster!

4. Demonstrate how to carefully break up soil and use small paintbrushes to move soil animals to a plastic plate or bowl for observation. If the animals move too fast to be observed live, students may kill them by putting a small amount of rubbing alcohol in the observation dishes (NOT on the soil sample). Once they have a representative specimen for identification, they should count other similar specimens alive.

5. Encourage students to use the white and black paper to help them find different kinds of soil animals. Some animals will show up better on a light background; others will be seen more easily on a dark background.

6. Partners should take turns finding soil animals, identifying them, and recording data.

7. Assist groups with hunting and identification as needed. You may need to provide a lot of encouragement as students first start hunting for soil animals. Soil animals are very small and like to hide!

8. CLEAN UP: If working inside, put used soil samples in designated buckets and organize work stations. If working outside, return living animals and soils to their source. Explain to students (or ask them to suggest reasons) why it is important to return living things to their original habitat.

9. Hand out Soil Fauna Analysis sheets. Each group reports their findings to create a class data pool, which is used in comparing the two soil communities.

10. See discussion suggestions in the Assessments section below.

ASSESSMENTS

• Students may hand in Soil Fauna Data Sheets and Soil Fauna Analysis handout.

• Class Discussion: Discuss differences in the soil community between the soils with 10s to 100s of roots and soils with 0 to 10 roots. When finished, students may summarize their learning on the Data Analysis handout.
  a. Which samples had the larger total number of soil animals?
  b. Which had the larger number of different kinds of soil animals?
  c. What kind of soil animal was the most abundant in each sample?
  d. What are some possible explanations for the differences?
  e. What roles do soil animals play in the food web?
Why are soil animals important? Guide students to considering the importance of soil animals to 1) breaking down and decomposing plant and animal matter, 2) mixing soil, 3) providing channels for water and air to move through soil, and 4) controlling the populations of pests and diseases.

Why are these services (1 through 4 above) valuable?

Most prairie roots live for many years, through all seasons. Crop roots like corn and soybeans grow during the spring and summer and die in the fall. Which kind of roots – prairie or crop – would support a more diverse and stable community of soil animals? Why do you think so?

Students could create graphs to show the types and frequencies of the soil fauna found in the two different soil samples. Describe the patterns in the data. Develop possible explanations for the patterns observed.

EXTENSIONS

1. Use the Soil Fauna ID cards to construct a soil food web on poster-sized paper, or draw a soil food web that includes the types of soil animals found in the activity and their relationship to roots.
2. Investigate different methods for trapping and quantifying soil fauna.
3. Construct Berlese funnels and use them to compare different soil samples. Sample soil under different types of vegetation, at different depths or at different seasons. This could be a great science fair project!

ADAPTATIONS

This activity can be adapted to a variety of age groups, from elementary through university.

For English Language Learners or students with reading challenges, point out connections between the images on the ID cards and the descriptions of the identifying features.

RESOURCES

STANDARDS

**MS-LS2-1** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

**MS-LS2-4** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

**MS–ESS3–3** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

**MS–LS2–5** Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

APPENDICES

A: Soil Fauna ID Cards
B: Soil Fauna Data Sheet
C: Soil Fauna Analysis Sheet
# Soil Fauna ID Cards

## Ant
*(Arthropods: Insects)*

- **Size:** 2-25 mm, depending on species
- **Identifying characteristics:** six legs, "elbowed" antennae
- **Diversity:** 12,000 species known
- **Role:** omnivore
- **Eats:** plant parts, fungi, other insects
- **Eaten by:** tiger beetles, amphibians, birds, spiders
- **Defenses:** Biting and stinging
- **Special abilities:** Communicate through chemical signals (pheromones); can lift more than 3 times body weight; live in colonies of 1000s; ants are 1/5 of all animal mass on earth

## Earthworm
*(Annelids)*

- **Size:** up to 8 cm
- **Identifying characteristics:** soft tube-like body made of many ring-like segments; no legs, antennae, or eyes
- **Diversity:** 3,000 species known
- **Role:** shredder
- **Eats:** dead plant material, soil fungi and bacteria
- **Eaten by:** birds, mammals, amphibians, reptiles
- **Defenses:** each segment has bristles, tough hairs that make it hard to pull a worm from its hole
- **Special abilities:** eats up to 1/3 of its weight in soil each day and deposits worm poop (castings) on the soil surface; night crawlers can dig as deep as 2 meters (6.5 feet)

## Beetles and Beetle Larva
*(Arthropods: Insects)*

- **Size:** 1 mm to 6 cm (even larger species are found in the tropics)
- **Identifying characteristics:** 6 legs, 2 antennae, adults have 2 pairs of wings
- **Diversity:** over 350,000 species
- **Roles:** herbivores, shredders, predators
- **Eats:** various foods depending on the species – living roots, dead plant or animal matter, other insects
- **Eaten by:** birds, mammals, amphibians, reptiles, predatory insects, and spiders
- **Defenses:** adults have hardened wing-cases
- **Special abilities:** larvae transform into flying adults; fireflies are beetles that produce chemical light for communication

## Millipede
*(Arthropods: Diplopoda)*

- **Size:** 2 mm to 35 cm (the largest are tropical species)
- **Identifying characteristics:** two pairs of legs per body segment; long tubular body
- **Diversity:** 7,000 species known worldwide
- **Role:** shredders
- **Eats:** dead plant material
- **Eaten by:** ants and other predatory arthropods, toads, mammals, and birds
- **Defenses:** curls up in a spiral shape; many kinds have stink glands called ozopores that ooze nasty smelling or toxic chemicals
- **Special abilities:** some species are brightly colored, and there is one kind of millipede in California that produces light through bioluminescence

## Centipede
*(Arthropods: Chilopoda)*

- **Size:** 3 mm to 30 cm
- **Identifying characteristics:** one pair of legs per body segment
- **Diversity:** 2,800 species known worldwide
- **Role:** predators
- **Eats:** smaller soil animals
- **Eaten by:** birds, reptiles, mammals, other kinds of centipedes
- **Defenses:** biting, running away, curling up and producing a chemical that repels predators
- **Special abilities:** has a pair of poison claws called forcipules that it uses to kill its prey; most are not strong enough to bite people; legs that are broken off can grow back

## Pill Bugs
*(Arthropods: Isopod)*

- **Size:** about 5-10 mm
- **Identifying characteristics:** 7 pairs of legs, 2 pairs of antennae
- **Diversity:** 3,800 species
- **Role:** shredders
- **Eats:** dead plant material
- **Eaten by:** centipedes, spiders, ants, birds, and amphibians
- **Defenses:** curl up inside armored shell
- **Special abilities:** more closely related to crabs and shrimp than to insects, isopods breathe with gills and must stay in damp places; eggs develop in the mother’s pouch
| **Spider**  
| (Arthropods: Arachnids) |
| **Size:** 1 mm to 35 mm body length  
| **Identifying characteristics:** 8 legs, 2 body sections, pair of fangs called chelicerae  
| **Diversity:** 45,700 species  
| **Role:** predators  
| **Eats:** mostly other arthropods  
| **Eaten by:** birds, amphibians, other arthropods  
| **Defenses:** camouflage, venom  
| **Special abilities:** female wolf spiders carry silk egg cases with them until the eggs hatch, then the baby spiders ride on her abdomen; the mother wolf spider feeds her babies by spitting up food for them |

| **Mite**  
| (Arthropods: Arachnids) |
| **Size:** less than 1 mm – 4 mm  
| **Identifying characteristics:** 8 legs, 2 body sections  
| **Diversity:** 6,600 species  
| **Role:** grazers  
| **Eats:** fungi and decaying plant matter  
| **Eaten by:** predatory soil arthropods such as pseudoscorpions, ants, and centipedes  
| **Defenses:** hiding and a tough exoskeleton  
| **Special abilities:** some female mites can reproduce without a mate |

| **Springtail**  
| (Arthropods: Collembola) |
| **Size:** less than 5 mm long  
| **Identifying characteristics:** 6 legs, two antennae, very small eyes, single tail  
| **Diversity:** 6,500 species  
| **Role:** grazers  
| **Eats:** fungi and decaying plant matter  
| **Eaten by:** ants and other predatory soil arthropods  
| **Defenses:** hiding  
| **Special abilities:** a 3 mm long springtail can leap up to 100 mm |

| **Doubletail**  
| (Arthropods: Diplura) |
| **Size:** 3-12 mm length  
| **Identifying characteristics:** 6 legs, 2 antennae, two "tails"  
| **Diversity:** 1000 species worldwide  
| **Roles:** grazers, predators  
| **Eats:** dead plant matter and fungi; some species are predators  
| **Eaten by:** predatory arthropods such as pseudoscorpions  
| **Defenses:** hiding  
| **Special abilities:** some species are adapted to living in caves |

| **Earwig**  
| (Arthropods: Insects) |
| **Size:** up to 2 cm  
| **Identifying characteristics:** 6 legs, 2 antennae, short wings, pair of pincers  
| **Diversity:** 2,000 species  
| **Role:** omnivores  
| **Eats:** various foods – plant parts, pollen, fungi, insects, spiders  
| **Eaten by:** birds, toads, centipedes, spiders, and wasps and other predatory insects  
| **Defenses:** pincers  
| **Special abilities:** females defend their eggs and young and feed their babies by spitting up food (regurgitation) |

| **Pseudoscorpion**  
| (Arthropods: Arachnids) |
| **Size:** 2-8 mm  
| **Identifying characteristics:** 8 legs, 2 main body sections, pincers on front pair of legs  
| **Diversity:** about 2000 known species  
| **Role:** predators  
| **Eats:** ants, soil mites, springtails, doubletails and other small arthropods  
| **Eaten by:** larger predatory soil arthropods  
| **Defenses:** hiding  
| **Special abilities:** grab prey and immobilize them using venomous pincers; females carry and protect their eggs and young |
Soil Fauna Data Sheet

Place a checkmark in the box that describes the abundance of roots in the soil sample:

- [ ] 0 to 10 roots
- [ ] 10s to 100s of roots

Record a tally mark for each organism found and identified.

<table>
<thead>
<tr>
<th>Type of organism</th>
<th>Observations</th>
<th>Role in food web</th>
<th>Tally Marks</th>
<th>Number (Sum of tally marks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ant</td>
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<td>Beetle or Larva</td>
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<td>Centipede</td>
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<td>Doubletail</td>
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<td>Earthworm</td>
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<td>Earwig</td>
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<td>Millipede</td>
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<td>Pill bug</td>
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<td>Pseudoscorpion</td>
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<td>Spider</td>
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<td>Springtail</td>
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</tbody>
</table>

Number of different types found:  

Most abundant type of soil animal:  

Total number of soil animals:
Soil Fauna Analysis

Share your group’s results with the class. Record what other groups found.

<table>
<thead>
<tr>
<th></th>
<th>Group Member Initials</th>
<th>Number of Different Types</th>
<th>Total Number of Soil Animals</th>
<th>Most Abundant Type of Soil Animal</th>
<th>Other Observations</th>
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<td>Averages</td>
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<td>10s to 100s of Roots</td>
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Discuss the class data. What do you notice about soil animals in samples with 0 to 10 roots compared with samples with 10s to 100s of roots?

1. Which soil had the larger total number of soil animals, on average?

_______________________________________________________________________________________________________

2. Which soil had the larger diversity (number of different types) of soil animals?

_______________________________________________________________________________________________________

3. What kind of soil animal was the most abundant in each soil sample?

_______________________________________________________________________________________________________
4. What do you think causes these differences?
____________________________________________________________________________________________________________
____________________________________________________________________________________________________________

5. What roles do different soil animals play in the food web?
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6. Why are soil animals important?
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____________________________________________________________________________________________________________
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7. Most prairie roots live for many years, through all seasons. Crop roots like corn and soybeans grow during the spring and summer and die in the fall. Which kind of roots – prairie or crop – would support a more diverse and stable community of soil animals? Why do you think so?
____________________________________________________________________________________________________________
____________________________________________________________________________________________________________
____________________________________________________________________________________________________________