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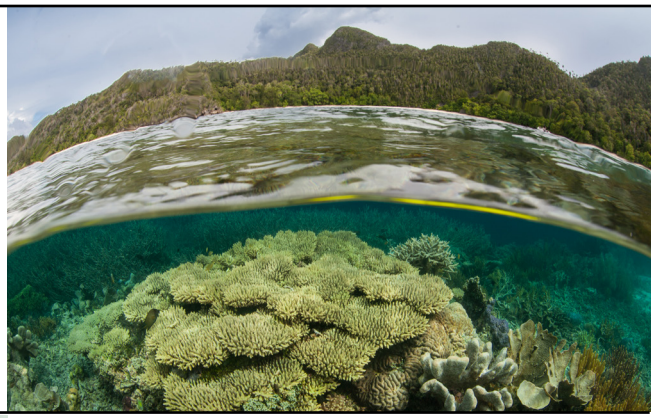

Part 6:

How can I balance the needs of people and soil organisms of my community?

SUSTAINABLE DEVELOPMENT GOALS

developed by

Smithsonian
Science Education Center

in collaboration with

iap SCIENCE HEALTH POLICY
the interacademy partnership

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PART 6: HOW CAN I BALANCE THE NEEDS OF PEOPLE AND SOIL ORGANISMS OF MY COMMUNITY?

Find out More!

For additional resources and activities, please visit the *Biodiversity!* StoryMap at https://bit.ly/3zvJ2Qh.

Planner

Timing note: *The time used for investigations, observations, and actions can vary. When different options are listed within an activity, some options may take longer than others.*

Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 1: What soil organisms are in our research area?					
Discover	Consider the soil organisms in your community and the senses you use to observe them.		*Part 3 Organizer* (Part 3, Task 1)	20 minutes	259
Understand	Use tools to investigate what soil organisms are in your research area.	• Paper • Pens or pencils • Optional observation tools	*My Research Area* (Part 1, Task 4, Act) *Investigation Tips* (Part 3, Task 1) *StoryMap extension available	20 minutes + investigation time	262
Act	Classify the soil organisms in your research area.	• Paper • Pens or pencils	*StoryMap extension available	30 minutes	272
Task 2: What do the soil organisms in our research area need to survive?					
Discover	Reflect on your experiences and how they relate to soil organisms.	• Paper • Pens or pencils		10 minutes	276
Understand	Investigate how the soil organisms in your research area meet their needs.	• Paper • Pens or pencils • Books (optional) • Computer (optional)	*Part 3 Organizer* (Part 3, Task 1) *Part 6 Organizer* (Task 1)	25 minutes + investigation time	277
Act	Share how soil organisms in your community get what they need to survive and decide how well your community is meeting those needs.	• Paper • Pens or pencils	*Part 6 Organizer* (Task 1)	20 minutes	281

Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 3: What are the conflicts between people and soil organisms in my community?					
Discover	Explore conflicts between people and soil organisms.	• Paper • Pens or pencils		10 minutes	282
Understand	Investigate conflicts between people and soil organisms in your research area.	• Paper • Pens or pencils • Optional observation materials		20 minutes + investigation time	283
Act	Create a shared list of the conflicts in your research area.	• Paper • Pens or pencils	*Part 6 Organizer* (Task 1)	30 minutes	290
Task 4: What are people already doing to balance the needs of people and soil organisms?					
Discover	Reflect on your thoughts and feelings about conflicts between people and soil organisms in your research area.	• Paper • Pens or pencils	*Part 6 Organizer* (Task 1) *My Identity Map* (Part 1, Task 2)	10 minutes	292
Understand	Explore what people in your community are doing about one conflict between people and living things in your research area.	• Paper • Pens or pencils	*Part 5 Organizer* (Task 1) *Part 3 Organizer* (Part 3, Task 1) *Part 2 Organizer* (Part 2, Task 2)	20 minutes + investigation time	294
Act	Prepare what you need to take action that will solve a conflict between people and plants in your research area.	• Paper • Pens or pencils		20 minutes	295

Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 5: How can I take action to balance needs in my community?					
Discover	Consider what you now know, think, and wonder about conflicts in your community.	• Paper • Pens or pencils	*Part 6 Organizer* (Task 1) *Balanced Community Goals* (Part 1, Task 3)	15 minutes	298
Understand	Decide on individual actions you will take to help your community.		*Part 6 Organizer* (Task 1)	15 minutes	299
Act	Put your idea for individual change into action and reflect on it.			10 minutes + action time	301

*StoryMap extension found at https://bit.ly/3zvJ2Qh

6

Part 6: How can I balance the needs of people and soil organisms of my community?

In Part 3 your team gathered information about the living things in your research area. You did an investigation about what people in your community need. This helped you explore how to balance the needs of people with the needs of living things in your community. But you need more information about your research area. More information will help you take more meaningful and sustainable action.

In this Part, you will learn more tips and tools for finding organisms in the **soil** of your research area. Soil is the mix of minerals, air, water, and living things that sits on Earth's surface. You may have also heard soil called dirt. When soil-like material is at the bottom of a body of water, it is called **sediment**. You can also find living things in sediment. Soil is the home to many different kinds of organisms including bacteria, fungi, and animals. Soil organisms can be found on land, in saltwater habitats, and freshwater habitats. Anywhere there is soil, there are soil organisms.

In this Part, you will observe the bacteria, fungi, and animals living in and near soil. If you have had difficulty finding or observing bacteria, fungi, and animals in the other Parts, this Part will give you the tools and skills to observe them. Though the soil is a habitat for some larger animals such as snakes, rabbits, or moles, this Part will only focus on smaller animals that live in the soil, such as insects, earthworms, or millipedes.

Why is it important that you learn about and observe soil organisms? All of the living things you observed in Parts 3, 4, and 5 depend on the organisms in the soil for their survival. Soil organisms break down living things that have died. They return those nutrients to the soil so that other living things can use them for energy. Soil organisms are the "hidden heroes" of Earth.

You will learn more about the conflicts that tend to happen between people and soil organisms. You will challenge yourself to start thinking of solutions that are inclusive and sustainable. All of this will help your team take action to balance the needs of people and other living things in your community in Part 7.

Remember: *In this guide you and your team are in charge. You can always change the instructions in the steps to make them work better for you and your team.*

Your Research Mentor

Sharing your experiences with others and learning from others' experiences is part of being a good action researcher. In Part 6, you will have a research mentor. A mentor is someone who has experience and can help guide you. The research mentor in this Part will help you understand some of the issues related to biodiversity in soil and how you can investigate and take action on those issues.

Meet Christine Sprunger, Your Part 6 Research Mentor

Meet Dr. Christine Sprunger. Christine (Kris-TEEN) is a soil scientist and professor at The Ohio State University in the United States. She is the leader of a laboratory that studies the living things in soil. Christine is most interested in **nematodes.** Nematodes are very small worms that live in soil.

She explains, "I am excited about nematodes because of where they fit in the soil food web. Some nematodes only feed on bacteria. Some nematodes only feed on fungi. Some nematodes eat plant roots. Some nematodes eat each other! We are starting to see that all these different nematodes impact the health of soil. We want to know how to manage the soil on farms to make sure that beneficial nematodes are thriving. Beneficial means good or helpful. Beneficial nematodes help crops grow. If the nematodes are thriving, they can increase **soil health**. And nematodes are also really sensitive to change, so they could help us tell how an ecosystem is responding to **climate change**."

Figure 6.1: A nematode seen through a microscope.

Christine has knowledge and perspectives that came from her identity. Since Christine is now working with you, it is important to understand who she is.

To help you, Christine filled out an identity map, just like you did in Part 1. Christine's identity map includes the following things:

- I am 33 years old
- I am Black, African American
- I was born in Haiti but I grew up in the United States
- I am adopted
- Haiti is important to me because I still have relatives there. One of the reasons I got interested in science was the tough environmental issues that Haiti has. That's really what motivated me to study soils.
- Originally I wanted to be a marine biologist—I was really impacted by the movie, "Free Willy"! And I grew up in Washington State, right on the coast. I was really interested in ocean systems. But as I got older and thought about environmental issues in Haiti, I realized that I really like soils. I can really link studying soil to food security issues and making environmental issues better, like climate change.

- I love anything to do with the outdoors. I like to spend time outside like going hiking. I also love biking. I have a stationary bike and do a lot of indoor biking. I really like trying different foods and trying new restaurants.
- I'm average height, 5 feet and 5 inches. I recently cut off most of my hair and am rocking the shorter hair! It's so much easier for maintenance. I wear glasses when I drive.
- I'm definitely an introvert, but a social introvert. I enjoy interacting with people but I definitely also like my downtime. I spend a lot of time reading and talking with close friends.
- I am the youngest of four daughters

Before you begin the rest of Part 3, think quietly to yourself about Christine's identity map.

- Are there things you have in common with Christine?
- Are there ways in which you are different from Christine?
- Can you see anything about Christine's identity that would help her understand how to balance the needs of people with the needs of soil organisms?

Task 1: What soil organisms are in our research area?

Your team did great work observing and **classifying** living things in Part 3. In this Part, you are going to focus on observing soil organisms. This task uses some of the same skills that you learned in Parts 3–5. But observing soil organisms is different from observing plants or animals. You will need new skills. You will learn those new skills in this task.

In this task you will explore the soil organisms that live in your research area. You will ***discover*** what you already know and feel about soil. You will also discover how to use your senses and other tools to help you find soil organisms. You will plan and carry out an investigation to ***understand*** what soil organisms are in your research area. Then you will ***act*** to classify and record these soil organisms.

Discover: *What soil organisms did we discover already?*

You may have already observed and classified some of the soil organisms in your research area in Part 3. Now your team will observe more soil organisms in your research area. Try to focus on paying attention to parts of your research area that you may not have explored before. You will learn from your research mentor about how to use your senses and other tools to search for soil organisms.

1. Think quietly to yourself and answer the following questions:
    a. What images do you think of when you think about soil?
    b. What smells do you think of when you think about soil?
    c. When is the last time you touched soil? What did it feel like against your skin?
    d. Do you remember seeing any living things in soil? What were they?
    e. Is soil important to you? Why or why not?
    f. What words do you or the people in your household or community use to describe soil?
2. Take out your *Part 3 Organizer*. Remember that your team recorded a list of the living things you found in your research area in Part 3. This list included soil organisms.

3. Discuss as a team:
    a. Did you observe and classify any soil organisms in Part 3?
    b. If you didn't, why do you think that is?
    c. What living things do you think you will find in the soil in your research area?
4. Christine and her team look for soil organisms as part of their research. Read the following to learn more from her about what lives in soil.

Christine says:

I always ask students to imagine a spoonful of soil. In that spoonful of soil, there are over one billion bacteria, strands of fungi as long as multiple football fields, hundreds of nematodes, and hundreds of protozoa. The soil ecosystem also has many sizes of **arthropods** such as ants and mites. It has earthworms. There are also pieces of **organic matter,** such as dead plants **decomposing**.

The soil ecosystem has a food web. Nematodes feed on bacteria, fungi, and plant roots. Earthworms and arthropods feed on nematodes. The earthworms also break down organic matter which the bacteria and fungi feed on, so it's all a big cycle. They are all creating this ecosystem and habitat for hundreds, thousands, and billions of living things. Soil would not exist without these organisms.

Figure 6.2: This pile of dirt contains an earthworm and white, thread-like fungi.

5. In the next activity your team will use your senses and other tools to find soil organisms in your research area. Learn about how Christine and her team use their senses and tools to help them observe soil organisms.

Christine says:

We use our sense of sight to first look at where the soil is. Is it in a forest? A farm? A prairie system? All of those soils are going to look really different. The soil on a farm that has a lot of planting and **tilling** going on might have fewer nutrients and less organic matter because they constantly get used up.

You can also look at the soil itself. People sometimes laugh at this, but when you line up different soils it can actually be really beautiful because there can be so many different shades. There are soils that are really red, soils that are dark and rich because the area has a history of burning, and you have light brown sandier soils that are from a desert.

Figure 6.3: Soils can have all different colors.

Touch is the next biggest sense we use. Even though we can see the different colors of soil it's still really important to understand what the soil is made up of by touching it. Scientists, farmers, and students can do the ribbon test. You basically squeeze a handful of moist soil through your thumb and fingers to make a ribbon of soil. How long the ribbon is can tell you about the health of the soil and an **estimate** of the things that are living in it.

Smell is also really important, especially in crop fields. You can tell if manure has been added or if the soil has been recently tilled.

We also use tools. The most important tool would be a shovel. We also use soil probes. They are these metal rods that help us get soil from deep places.

We use the cameras on our phones to take pictures of where we get our soil samples. We also have a tool made of clear tubes that go into the ground near plant roots. We stick a long probe with a camera at the end down the tubes so we can take pictures of the roots.

6. Think about how Christine and her team use their senses and other tools to find soil organisms in their research area. Discuss the following questions as a team:
   a. Could you use any of the same senses or tools that Christine and her team used?
   b. What other senses or tools do you want to use?
7. Your team will plan and carry out an investigation in the next activity. You will use your senses and other tools to find soil organisms in your research area.

Understand: *How can we investigate our research area?*

In the last activity you thought about how you can use your senses or other tools to find soil organisms in your research area. Now your team will use this information to plan and carry out an investigation to observe the soil organisms in your research area. Just like in Part 3, don't worry about trying to find all of the soil organisms in your research area in this activity. Just do the best you can.

1. Gather your team and take out the *My Research Area* map you made in Part 1, Task 4, Act. Recall where your research area is.
2. Read *Investigation Instructions* for more information about how to observe soil organisms in your research area.

Investigation Instructions

Where to investigate:

1. Review the tips from the Part 3, Task 1, Understand activity.
2. You can go back and make observations in the same parts of your research area that you did in Part 3. Or you can make observations in a new part of your research area.
3. Soil can be found almost everywhere. Look for soil in cracks between sidewalks or bricks, next to buildings, along a road, a public park, a raised garden bed, or a container garden. Even small amounts of soil can be the home to living things.
4. Remember to look for soil underwater, too. Look in puddles, ponds, streams, rivers, marshes, wetlands, tidepools, and oceans for the layer of soil, sand, or sediment at the bottom.
5. You can also look for soil organisms in something called **litter**. Litter is the layer of dead and decomposing plants that sit on top of the soil. For example, after the growing season is over there might be a layer of dead leaves and twigs on the ground. Some soil organisms spend part of their lives in that layer of litter.
6. Turn over objects that are sitting on top of the soil to look for organisms that are underneath. For example, you could look under fallen branches and logs, small rocks, cinder blocks, bins, or boxes.

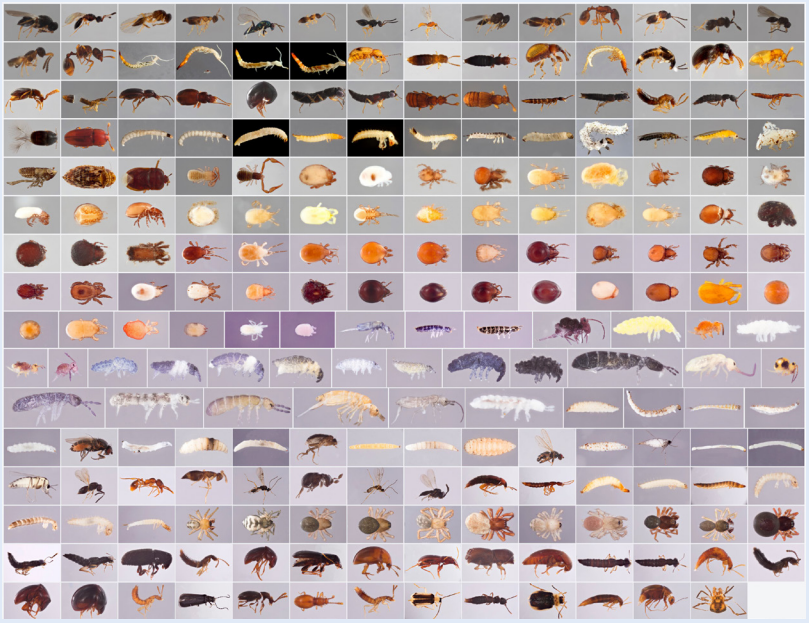

Figure 6.4: This photo shows over 200 kinds of arthropods that were found in leaf litter by a scientist in North Carolina.

Tools you can use:

1. Review the tips from the Part 3, Task 1, Understand activity that describe how to use your senses and other tools, such as a magnifying glass, a camera, or paper and a writing tool. Remember that you also thought about how you could use your senses in the Discover activity.

> **⚠ Emotional Safety Tip**
>
> Remember to be an inclusive team member. Every person on your team brings different skills and perspectives. Some members of your team may not want to or be able to use all of their senses. That is fine. Work with your teammates to find a way for everyone to participate and feel comfortable

2. Some soil organisms are very small. It can be hard to see details of the soil organisms. A camera that can zoom or a hand lens can help you see small soil organisms. If you do not have either tool you can make a simple hand lens out of a plastic bottle:
   a. Find a clear plastic bottle with a curved top.
   b. Cut a small circle out of the curved part of the bottle.

c. Pour a small amount of water into the curved part of the bottle.
d. Hold the curved part of the bottle over the soil organism you are trying to see. The curve of the bottle and the water will magnify it.

3. Always use digging tools to help you see under the soil. There are many kinds of tools that can help you dig, such as a shovel, a **trowel**, a spoon, a file, a sharpened stick or rock, or a metal spatula. Do not dig with your bare hands.
4. Wear sturdy gloves to protect your hands when handling the soil. You can use gardening gloves or rubber gloves. It is important to protect your hands from harmful objects that may be in soil such as glass, metal, rocks, or other sharp surfaces.

Tips for doing this investigation:

1. Review the tips from the Part 3, Task 1, Understand activity.
2. Try to conduct your investigations during the growing season when soil biodiversity will be highest.
3. Soil can be easier to explore when it is damp. It can be very difficult to dig into dry soil.
4. If the soil is cold or frozen there may not be many soil organisms that are active. It will also be difficult to dig into the soil.
5. Remember that there are three major types of soil organisms that you might observe: bacteria, fungi, and animals. Some animals and fungi might be large enough for you to observe easily. For example, some fungi have large parts that grow above the soil or litter. But some fungi are very small and can only be found underground, at the tip of plant roots. They are much harder to see. Bacteria are also too small for you to see without using a microscope. Read the *Types of Soil Investigations* section for tips on how to find evidence of all kinds of soil organisms.
6. Because many soil organisms are decomposers, look for them in places where organic material is breaking down. For example, you may find fungi near a rotting log. You may also be more likely to find certain soil organisms in parts of your research area that are damp. Earthworms and certain mushrooms are examples of soil organisms that like to live in damp environments.

Figure 6.5: Part of this tree has fallen down and started to decompose. This would be a good place to start your search for soil organisms.

Safety Tips for observing outside:

Ask your teacher first for guidelines. They will know what is safest in your community.

⚠ Physical Safety Tip

Do not observe a research area by yourself. Always work with at least one other person, which could be an adult or a teammate. Notice if your teammates are uncomfortable or if they feel unsafe. Offer to pause the investigation or move to another part of the research area.

Do not use your sense of taste to try to observe soil organisms. Do not touch soil organisms that you are unsure are safe to touch. For example, some soil organisms may bite or sting.

Always wash your hands before and after handling soil and soil organisms. Wear sturdy gloves to protect your hands when handling soil.

Make sure it is safe to dig in your research area before doing any investigations that involve digging. Some countries have phone numbers you can call to find out if an area has buried electric or cable lines or other harmful materials. Be sure to ask an adult for help before digging.

⚠ Emotional Safety Tip

You may not want to touch the organisms that you find. Or you might be nervous or scared around certain soil organisms, such as insects, spiders, and worms. It is okay to find another way to help the team.

Do not be discouraged if it is difficult to find soil organisms. Every research area is different. Some areas may have many soil organisms and some may have very few. It is not your fault if you have trouble finding soil organisms. Just practice using your senses and other tools to do your investigation. If you feel sad or wish there were more soil organisms in your research area, remember that you will take action to make this possible!

Types of Soil Investigations

Growth Plate

In this investigation you will make **growth plates**. A growth plate is a surface that is covered in gelatin and nutrients. Bacteria and fungi are able to grow on the surface.

1. Ask an adult to help you boil a cup of water.
2. Add a teaspoon of unflavored gelatin, a teaspoon of sugar, and teaspoon of beef stock powder or a beef bouillon cube to the boiling water.
3. Stir until all the ingredients are dissolved. This should take about 1 minute.
4. Turn off the heat and let the mixture cool for about 10 minutes.
5. Pour the mixture into individual containers such as clear, round plastic containers with lids, plastic cups with lids, or foil muffin tins. Fill each container about 1/3rd of the way with the mixture.
6. Place a cover loosely on the containers and allow the mixture to cool all the way. You can store the containers in a cool, dry place such as a refrigerator, food cellar, or basement until you are ready to use them.
7. Get a piece of litter from your research area, such as a leaf, twig, and piece of bark. Or get an object from on or under the soil such as a rock or stone.

8. Press the object gently onto the surface of a growth plate. Do not push it down into the mixture. Place the cover back onto the growth plate immediately after. Repeat with a new object and new plate as often as you would like.
9. Place the growth plates in a warm place and leave them alone for 3 to 5 days.
10. Check the plates after 3 to 5 days. Notice if they have anything growing in them. Fungi will often look like fuzzy, thread-like material. Bacteria will often look like circular spots. The growth plate can show you if those kinds of soil organisms are growing in your research area.

Berlese Funnel

In this investigation you will make a **Berlese funnel** to observe the animals living in the soil and litter of your research area. If you would like more instructions or to see an example of a Berlese funnel, you can view a setup video in the *Biodiversity!* StoryMap.

1. Ask an adult for help in cutting a plastic drinking bottle in half. A 1-liter bottle is a good size to use.
2. If you would like, you can pour a few centimeters of soapy water or rubbing alcohol in the bottom half of the bottle. This liquid will kill and preserve any animals that fall down the funnel. If you would prefer not to do that, you can leave the liquid out and return all the animals to their habitat once the experiment is over.
3. Flip the top of the bottle so the mouth of the bottle faces down. Place it into the bottom of the bottle and tape the parts of the bottle together to form a seal.
4. Line the inside of the top part of the bottle with thin mesh. The mesh can be wire or plastic. It should have openings of about ¼ inch. Make sure the mesh sits over the mouth opening in the bottle. This will allow animals to move to the bottom of the Berlese funnel.
5. Collect some leaf litter and soil from your research area. Place it in the top part of the bottle over the mesh.
6. Cover the outside of the bottom part of the bottle with dark paper or fabric (like a t-shirt).

7. Place the Berlese funnel under a light. The light will cause the animals to move downward to the dark part of the funnel.
8. Leave the funnel alone for 3 to 5 days.
9. Open the funnel. If you used liquid, pour the liquid into a wide, flat container with raised sides like a cooking dish. If you did not use liquid, you can still use a wide flat container with raised sides to observe any animals. But do your observation outdoors in case the animals in your sample begin to move away from the container.
10. You will learn more about how to classify the animals you found in the Act activity.

Aquatic Animals

In this investigation you will use mesh bags and dried leaves to trap and observe any organisms living in the leaf litter underwater. The instructions in this section will help you do a very simple version of this activity. If you would like to do a more detailed version of this activity you can go to the Stroud Water Research Network Leaf Pack Activity website. The website is listed in the *Biodiversity!* StoryMap. The Leaf Pack activity is available in English and Spanish.

1. Find a source of shallow water in your research area, such as a stream. Make sure you have permission to place something in this water.
2. Collect dried leaves from your research site. If you only have fresh leaves during this time of the year, pick some fresh leaves and allow them to dry for several weeks. You want dried leaves that snap in half when you bend them. If the dried leaves crumble when you bend them they are too dry.
3. Collect a mesh bag. You can usually find these bags at the grocery store. They are usually used to hold onions or fruits.
4. Place dried leaves inside the mesh bag until it is loosely full. Make sure the bag has a knot at one end before placing the leaves inside.
5. Close the mesh bag by tying a knot at the other end.
6. Thread a long string through the mesh bag. This string will allow you to keep the bag in one place in the stream.
7. Find a place in the stream where leaves and other material are collecting in the current, such as against a rock. Place the mesh bag in that part of the stream. Use the string to secure it to a heavy rock in the stream so it will not float away.

8. Write down where you placed your mesh bag. You can also make a mark on the side of the stream to help you find the mesh bag again, such as planting a bright flag in the ground.
9. Leave the mesh bag for 3 to 4 weeks.
10. Come back to the stream. Fill a bucket or other container with water from the stream.
11. Collect the mesh bag from the stream and place it in a bucket or other container filled with stream water.
12. Untie the knot in the bag and pour all the leaves into the bucket. Pour more stream water over the mesh to fully rinse all the leaves and organisms from the bag.
13. If you can, pour the bucket of leaves through a sieve with very small openings. This can help trap the leaves and organisms while allowing the stream sediment to pass through. If you can do this step, dump the contents of the sieve into a flat, wide container filled with a few inches of stream water.
14. If you cannot do step 13, pour the contents of the bucket into a flat, wide container.
15. Observe the organisms in the container.
16. Feel the leaves in the container. Do they feel slimy or like they have a thin film on them? That is likely bacteria and fungi. Bacteria and fungi grow on dead material and help decompose it.
17. Observe the animals in the container. You will likely see many kinds of arthropods. These are animals with jointed bodies, pairs of limbs, and hard exoskeletons. Spiders and insects are some examples of arthropods.
18. You will learn more about how to classify the organisms you found in the Act activity.
19. When you get to the Task 2, Understand activity be sure to review the kinds of organisms you found in your Leaf Pack. They can help you understand if the water is healthy or polluted. More information can be found on the Leaf Pack website.

Figure 6.6: Search for soil and sediment organisms in water like this small stream. Notice the pack of leaves that have naturally formed near some rocks in the stream. That would be a good place to start your search.

3. If finding soil organisms outside doesn't sound like the right investigation for your team, that's okay! You can pick another way to collect information about your research area.
    a. You can use online tools, such as iNaturalist, to find out what soil organisms have already been found in your research area. More information about these tools is in the *Biodiversity!* StoryMap.
    b. You can use books, lists, websites, videos, artwork, photos, stories, or other records of soil organisms in your research area. Try to use records that have been made recently to make sure you are only observing soil organisms that still live in your research area.

c. You can write, call, or talk to local gardeners, farmers, scientists, researchers, older people who have lived in the community a long time, or other experts on soil organisms in your research area. Ask them to describe what soil organisms they have observed in your research area.

4. Decide as a team how you will investigate.
5. Remember, including everyone on your team is important. Try to pick a way to investigate that allows everyone to participate. Don't forget to think about the timing, comfort, location, and format of your investigation to make sure everyone on the team feels included. You can reread Part 2, Task 2, Understand if you need more information about making your investigation inclusive.
6. Next, work with your team to plan how you will do your investigation. For example, if you decide to do an observation, decide which teammates will observe which parts of the research area. Decide how long you will spend finding soil organisms. Decide how you will record the soil organisms you find and who will do the recording.
7. Finally, do your investigation with your team.

Act: *How can we classify the soil organisms in our research area?*

Your team has just completed a very important step in helping to balance the needs of people and soil organisms in your community. You observed the kinds of soil organisms in your research area. Now you will classify these soil organisms. This information will help you complete the rest of this Part and get ready to take action in Part 7 to create a balanced community.

1. Your team is going to **classify** the soil organisms you just found in your research area. Classify means to name or identify something and to sort it into a group. Classifying living things can help you understand more about the biodiversity in your research area. Remember that biodiversity is a measurement of how many different types of living things are in an area. To measure biodiversity in your research area, you need to know how many different kinds of soil organisms you observed.
2. Read *Tools to Help Classify Soil Organisms* for more information about how to classify soil organisms in your research area.

Tools to Help Classify Soil Organisms

1. A **field guide** is a tool that has the names, images, and descriptions of soil organisms in an area. Field guides may be printed (such as books) or online. Because there are so many different kinds of living things in soil, you may need to look at a key for one kind of living thing at a time. For example, you could find a field guide just for insects.
2. You can also use a **dichotomous key**. This is a tool that asks you questions about the parts of a soil organism to help you classify it. Try finding a dichotomous key for soil organisms in your area of the world. Because there are so many different kinds of living things in soil, you may need to look at a key for one kind of living thing at a time. For example, you could find a dichotomous key just for fungi.
3. A ruler can help you measure the soil organisms you find. Measurements can help you tell animals apart.
4. You can use an online tool such as the iNaturalist website, which is also known as a community science tool. People in a community take photos or describe what soil organisms they have noticed in their area. They send the photos and descriptions to scientists through the website. The scientists help identify what the soil organisms are. This helps scientists and community members keep a record of what kinds of soil organisms are in an area. More information for iNaturalist is in the *Biodiversity!* StoryMap**.**
5. Communicate with a person who is respected in your community because of their knowledge of the environment and soil organisms. This might be a gardener, a farmer, a soil scientist, someone who has lived in the community for a long time, someone with traditional knowledge, or someone who works or volunteers in the outdoors.
6. If you do not have a field guide, your team can come up with your own names for soil organisms in your research area. Review the case study in Part 3, Task 1, Act for more information.

Tips to Help Classify Soil Organisms

1. If you don't have access to any tools to help you classify, just try to notice if the soil organisms you observed in your research area are different from each

other. For example, you might observe that one animal in your research area has a long, dry body with many legs and antennae, and another soil organism has a smooth, long, moist body with no legs or antennae. Even though you don't know the names of these soil organisms, you can tell that they are not the same. Record that you observed two different soil organisms in your research area.

3. Remember from the case study in Part 3, Task 1, Act that there are many ways to classify a living thing. No matter which way you choose to classify the soil organisms in your area, remember that your way is valuable because it came from you.
4. Work with your team. Title a sheet of paper or a digital document *Part 6 Organizer*. Make three columns just like you did for your *Part 3 Organizer*. Write the words "Know", "Think," and "Wonder" at the top of the columns.
5. Create a list in the *Know* column of the soil organisms that your team found in the research area.
    a. Record the name of each soil organism you found. If you were not able to find or create a name you can write a description, use a symbol, or make a drawing.
    b. List how many of that soil organism you found.
    c. If several team members found the same soil organism, combine those numbers and record the total. For example, if one person found 10 carpenter ants in their part of the research area and another person found 12 carpenter ants in their part of the research area, record "twenty-two carpenter ants."
    d. You may have found evidence of soil organisms even if you could not see the actual organism. For example, you may have found slimy leaves. This tells you the leaves probably have bacteria on them even if you aren't able to see the bacteria. You can record this in the *Know* column.
6. Consider your *Know* column. Discuss the following questions as a team:
    a. Did your research area have many different kinds of soil organisms?
    b. Did it have the same kind of soil organisms over and over?
    c. Did it have very few soil organisms?
    d. Do you think there might be soil organisms living there that you weren't able to observe?

7. Answer the following questions in the *Think* column:
    a. How does your team feel about the kinds of soil organisms in your research area? Are there soil organisms you like more than others?
    b. Do you wish you had more kinds of soil organisms in your research area?
    c. Which soil organisms did you notice most easily? Why do you think that is?
    d. Are any soil organisms more important to you than others? Why or why not?
    e. Why do you think some soils have more organisms than others?
8. Is there anything else you would like to investigate about the soil organisms in your research area? Or anything else you would like to know? Record your answers in the *Wonder* column.
9. Keep the *Part 6 Organizer* in a safe place.

Task 2: What do the soil organisms in our research area need to survive?

In Task 1 your team observed as many soil organisms as you could in your research area. Now it is time to figure out how those soil organisms are meeting their needs. First, you will ***discover*** how your experiences are related to soil organisms. Then, you will use an investigation to ***understand*** how the soil organisms in your research area meet their needs. Finally, you will ***act*** on this information to record those needs and think about how well your research area is able to meet them.

Discover: *How are soil organisms important to me and my community?*

In this activity you are going to think about how your experiences relate to how soil organisms meet their needs.

1. Think about the following questions by yourself:
    a. Imagine you needed to get rid of a piece of waste, such as uneaten food, plastic packaging, or paper?
    b. How does it help you to get the waste out of your home?
    c. What would happen if you could not get rid of waste?
    d. What do you do with items in your household that can be recycled, such as glass, paper, and certain kinds of plastic?
    e. How can recycling help you, your local community, and the global community?
2. Now, share your answers with your team.
3. Read *Decomposers*. Then answer the questions that follow.

Decomposers

Many soil organisms meet their needs for energy by decomposing organisms that have died. Decomposition breaks down the dead organism into very, very small parts. This makes space in the environment for living things to grow and live.

When bacteria, fungi, and animals decompose an organism some of the nutrients in that organism are returned to the soil. Those nutrients become available for another organism to use for energy.

4. Using the information from *Decomposers*, answer these questions with your team:
   a. How are the actions of soil organisms similar to the actions you described in step 1?
   b. What would happen in your community if soil organisms did not decompose organisms that died?

Understand: *How can we investigate what soil organisms need to survive?*

In the Part 3, Task 2, Understand activity your team did an investigation of how the living things in your research area meet their needs. That investigation may have already included some of the soil organisms from your research area. Now you are going to add to that investigation by finding out more about the soil organisms you observed in the Part 6, Task 1, Understand activity.

1. Gather your team together and take out your *Part 3 Organizer* and your *Part 6 Organizer*.
2. Read through the list of soil organisms in the *Know* columns. Remind yourself of what soil organisms are in your research area.
3. Now your team will plan an investigation into how the soil organisms in your area meet their needs. Read *What Do Soil Organisms Need?* to find out more about the basic needs of soil organisms.

What Do Soil Organisms Need?

Soil organisms need a source of energy, water, and space.

Many soil organisms rely on organic matter as a source of energy. Some examples of organic matter are dead plants and animals. When these living things die, they decompose and return nutrients to the soil.

Soil organisms need water. Water must be able to absorb down into the soil to reach soil organisms below the surface. The water should be clean and free of pollution.

Soil organisms need space to live in the soil. It is also helpful if that space is not disturbed very often. This means that the soil is not dug up, moved, or tilled.

4. Before you begin your investigation, read the following information from your research mentor, Christine. She explains what the soil organisms in her research area need.

Christine says . . .

Nematodes can live in fresh water, salt water, and land **ecosystems**. Nematodes don't require that much space as they are on average 1/500th of an inch!

The awesome thing about nematodes is that they really depend on other parts of the food web for survival. Nematodes are specialists, so certain nematodes are fungivores and only feed on fungi. Other nematodes are bacterivores and only feed on bacteria. Some feed on other nematodes (they are predators!). The last group are parasitic nematodes that feed on plant roots. So nematodes will thrive based on if their chosen food source is plentiful.

5. Discuss how you will investigate the needs of soil organisms in your research area. There are many ways to investigate. You could:
   a. Plan an observation like you did in the Part 3, Task 2, Understand activity. You could observe the spaces that have soil in your research area. Just like in Part 3, be aware that some needs may be more difficult to observe than others. Use the following questions as a guide:
      - Where does the organic matter on or in the soil come from?
      - Where does water come from in your research area? Rain? Waterways such as streams, rivers, or ponds?
      - How much space in the research area has soil?

b. Interview an expert in your community on the phone, online, or in person. An interview is similar to the oral history you collected in Part 2, Task 2, Understand. But instead of asking about the past you will ask people about what they know now. Go back to Part 2, Task 2, Understand if you need help with this kind of investigation. You could interview:
   - Older people who have lived in the community a long time and know about local soil organisms
   - A person who is respected in your community because of their knowledge of the environment and soil organisms
   - Someone with traditional knowledge of soil organisms or how to manage soil
   - Farmers, gardeners, landscapers, or other people who work in the soil
   - A scientist that studies soil organisms
   - A volunteer at a local nature preserve or wildlife refuge

c. Use books, websites, videos, artwork, audio recordings, or other records of what the soil organisms in your research area need. Try to use records that have been made recently to make sure you are only learning about the soil organisms that still live in your research area.

d. Think of your own way to collect information.

6. It might be difficult to get all of the information you need from just one kind of investigation. You may need to combine more than one kind.

7. Decide what kind of information you want from this investigation.

   a. Soil organisms have three basic needs: a source of energy, water, and space. You will need to find out how the soil organisms in your research area are meeting these needs. You can also begin to notice if the soil organisms in your research area are having trouble meeting their needs. Use the following questions as a guide:
      - Organic Matter:
         1. Is there organic matter in your research area?
         2. When plants and animals die, do people remove them or can they decompose in the soil? For example, when a tree dies or falls over, is it cut up and taken away?

- Water:
    1. When it rains does the water quickly run off the surface of the soil without absorbing? Or does some of it absorb into the soil?
    2. Is there any pollution in your research area that could absorb into the soil?
- Space:
    1. How much of your research area has soil?
    2. Are there any spaces in your research area where something is covering the soil, such as pavement or a building?
    3. Does the soil look like it has been disturbed? If so, who or what is disturbing it?
    4. Are there any soil organisms in your research area that people do not like or are trying to get rid of? What do they do or use to try to get rid of those organisms?

8. Plan your investigation. Decide what needs to be done and who will do each part. You can:
    a. Split up the list of soil organisms from the *Know* columns among your team members.
    b. Decide how you want to record the information from your investigations. You can write it down, draw pictures, record your voice, or find another way.
    c. Decide who will lead the investigation and who will record the information from those investigations.
9. Work with your team to do your investigation.

Figure 6.7: A group of mushrooms has started growing after a heavy rainstorm. This species of mushroom needs lots of water to grow and meet its needs.

Act: *How can we share what we learned about what soil organisms need?*

Your team has investigated the needs of soil organisms in your research area. Now, your team will share what you observed and use that information to decide how well your community is meeting those needs.

1. Take out the information you recorded from the Understand activity. Take out your *Part 6 Organizer*.
2. Have the team leader record what they found out in the Understand activity. They should put their answers in the *Know* column. For example, the team leader may have learned from an observation that the soil organisms in your research area get their water from rain.
3. Let the team leader know if they describe a need that you also found in the investigation. Circle that need or make some other mark next to it. This will help you record that this is something that more than one soil organism needs or wants.
4. Next, share any needs you learned about in the investigation that haven't already been listed. Have the team leader record your observations or add them yourself if you are working with a digital or shared document.
5. You should now have a list of what the soil organisms in your research area need.
6. Discuss what you learned about in the investigation as a team. Record your thoughts in the *Think* column.
    a. What needs are shared by many different kinds of soil organisms in your research area?
    b. Are any soil organisms in the research area having trouble meeting their needs?
7. Take out your *Part 2 Organizer* or the information from your investigation in Part 2, Task 2, Act. Remember that you investigated how your community changed over time. Information from this investigation can help your team discuss how well your community is meeting the needs of soil organisms. Discuss:
    a. In the past did your community have a resource that helped meet the needs of soil organisms, such as a forest that produced a lot of organic matter when leaves and branches fell?
    b. What happened to that resource?
    c. Why did it change over time?

Task 3: What are the conflicts between people and soil organisms in my community?

Your team found out information about the needs of soil organisms in your research area. Now, you will ***discover*** how you feel about conflicts between people and soil. You will use an investigation to ***understand*** if there is evidence of conflict between soil organisms and people in your research area. You will ***act*** on the information from the investigation to identify the problems in your community and start thinking about how to solve them.

Discover: *How do I feel about the soil organisms in my community?*

In the Task 1, Understand activity you discovered the variety of soil organisms in your research area. Remember that the living things in soil help break down organic matter and return those nutrients to the ecosystem. Many other organisms depend on the living things in soil to survive.

But people also use the land and water where soil organisms live. In this activity you will learn how you feel about conflicts between soil organisms and people. In the Understand activity you will investigate some of these conflicts.

1. You are going to read a few statements and decide how you feel about them.
2. Choose whether you agree, are not sure, or disagree.
3. Share that information with your teammates. You could say it, write it, draw it, share it online, or move to different places in a classroom or learning space. For example, the corners of a classroom could have signs that read, "I agree," "I disagree," or "I'm not sure," and you could move to the corner that matches what you think.
4. Read the following statements and decide how you feel:
    a. Some soil organisms are pests and it is okay to kill them with chemicals.
    b. It is okay to build a sidewalk over soil so people can safely move around their space.
    c. All dead plants and animals should be cleared out of parks that people use.
    d. It is okay if chemicals get into a stream because they will just wash away.

5. Read the following information from your research mentor, Christine. She explains some of the conflicts between people and soil organisms.

Christine says . . .

There is this huge conflict of, "We need to grow food to feed people," and we know that food security is a really important issue around the world. There are a lot of places where they aren't able to produce enough food to feed their population. But food production is really intensive and it actually degrades the soil a lot of times. It can release greenhouse gases back into the atmosphere which can cause climate change, which we know is probably the most pressing issue of our time.

Agriculture has a role in contributing to climate change, but it also has a role in mitigating climate change. We are trying to understand how soil organisms are processing soil carbon. Are they helping to keep it in the soil instead of being released into the atmosphere? What kind of management practices would help the soil organisms keep carbon in the soil?

Pollution is a problem. Especially in urban soils. I live in Ohio, so a lot of people in Cleveland are working to use different urban spaces for gardens. But a lot of that soil is contaminated with lead. They have to do a lot more testing than we do to make sure the soil is safe to plant food that people are going to eat. As more people live in cities, thinking about how our soils might be polluted is really important.

Understand: *How can we find out more about the conflicts in our research area?*

When soil organisms can't meet their needs, they may get stressed and some may die. The organisms that can move may leave. All of this lowers the biodiversity in an area. Remember that biodiversity is the measure of different living things in an area. Many living things depend on soil organisms to survive, so a decrease in soil organism biodiversity can cause huge problems in the rest of an ecosystem.

Your team is trying to figure out how to solve problems related to biodiversity in your research area. But it can be hard to observe these conflicts between soil organisms and people because many of these living things are small or hidden under the soil. In this activity, you and your team will learn how to observe evidence that soil organisms are stressed, have moved, or have died.

1. As a team, think back to what you observed in the Task 2, Understand activity. Discuss the following question as a team:

   a.Did you notice that any soil organisms had trouble meeting their needs?
2. Gather your team together and take out your *Part 3 Organizer* and your *Part 6 Organizer*.
3. Read through the list of soil organisms in the *Know* columns. Remind yourself of what soil organisms are in your research area.
4. Now your team will do an investigation of your research area. You will find out if there is any evidence of conflict between people and soil organisms.
5. Use the following investigations to help you observe evidence of conflicts in the research area.

⚠ Physical Safety Tip

Do not observe a research area by yourself. Always work with at least one other person, which could be an adult or a teammate. Notice if your teammates are uncomfortable or if they feel unsafe. Offer to pause the investigation or move to another part of the research area.

Always wash your hands before and after handling soil and soil organisms.

Make sure it is safe to dig in your research area before doing any investigations that involve digging. Some countries have phone numbers you can call to find out if an area has buried electric or cable lines or other harmful materials. Be sure to ask an adult for help before digging.

Wear sturdy gloves to protect your hands when handling the soil. You can use gardening gloves or rubber gloves. It is important to protect your hands from objects in the soil that you cannot see like glass, metal, rocks, or other sharp surfaces.

Soil Tests

Soil Health Test

This investigation will help you observe if the soil organisms in your research area are healthy or if they are having trouble meeting their needs. If you find an area that seems to have unhealthy soil, observe how humans are using that area. Is there anything about the way humans are using it that might make it harder for soil organisms to meet their needs?

1. Get a piece of white cotton clothing, such as a cotton rag or t-shirt. The item must not be dyed.
2. Find a place in your research area where it is okay to bury the clothing.
3. Dig a hole at least 8 cm deep.
4. Place the clothing in the hole.
5. Completely cover the clothing with soil and refill the hole.
6. Mark the place with a stick, a rock, a landscape flag, or another marker.
7. Dig up the clothing 8 weeks later. You can check the clothing more often if you would like in that 8-week period, but it is best to leave the soil alone.
8. Check to see if the clothing has broken down. If it has, then you have a healthy community of soil animals, fungi, and bacteria. The soil organisms have decomposed the organic matter in the clothing.
9. You can expand this investigation by burying clothing in several different spots in your research area and comparing the results. This will tell you about the soil health in each location.
    a. Compare a spot that is heavily used by humans, like a path, to a spot that is left alone.
    b. Compare a spot that gets more rainfall to one that is more sheltered.
    c. Compare an area that only has one kind of plant, such as a lawn, to an area with many different kinds of native plants.
10. If you do not have clothing you can use, you can also do this investigation with teabags. Learn more about how to do this investigation in the *Biodiversity!* StoryMap.

Smell Test

1. Dig up a handful of soil from several places in your research area.
2. Place each handful in its own container.
3. Smell each container of soil.
4. Does any of the soil smell sour or rotten? This can mean the soil lacks oxygen. A lack of oxygen can make it hard for some soil organisms to survive and meet their needs.
5. If the soil smells sour or rotten, notice how the soil in that area is being used. Is this a space that people are also using? If so, how are they using it?

Soil Compaction Test

In this investigation you will find out if the soil in your research area is **compacted**. Compacted means packed tightly or pressed down. Compacted soil does not have space for air or water. It is harder for soil organisms to meet their needs in compacted soil. Soil can be compacted when humans use an area of soil over and over again. For example, the soil on a walking path or a garden can become compacted.

1. Find a place in your research area that has soil that is used often by humans. Find another place that has soil that is left alone.
2. Ask an adult to help you find a wire to use in the test. This wire should be a few feet long. You want the wire to be rigid but bendable. You should be able to bend it using your hands. But the wire should not bend itself when you shake or wiggle it. A wire hanger or a wire landscape flag can work. Or, if you are able, you can purchase 10-gauge high-tensile wire.
3. Bend one end of the wire to make a handle.
4. Get a ruler or tape measure.
5. Go to the first place you want to test.
6. Using the handle, try to press the wire into the soil until it cannot go any further. The wire may start to bend. That is a sign to stop pushing.
7. Use your finger to mark the place where the wire meets the soil.
8. Pull the wire out while keeping your finger in place.
9. Measure the distance from the end of the wire to your finger. This will tell you how far into the soil the wire went.

10. You may feel the wire hit a rock or other object in the soil. If that happens you can stop the test. Repeat the test in soil a few centimeters away to try to avoid that object.
11. Record the results from the first place you tested.
12. Then, repeat the soil compaction test in the second place in your research area.
13. Record the results from the second place you tested.
14. Compare the results. Where did the wire go further into the soil? That area is less compacted.
15. If the wire went less than 20 cm into the soil, your soil is likely compacted. If the wire went between 20 and 30 cm, the soil might be slightly compacted. If the wire went more than 30 cm into the soil, the soil is likely not compacted.
16. If the soil is compacted, notice how the soil in that area is being used. Is this a space that people are also using? If so, how are they using it?

Soil Stability Test

This investigation will help you test how well the soil in your area sticks together. Soil that sticks together is called **stable** soil.

Why is it important for soil to be stable? Soil is exposed to many different kinds of forces. Rainwater, wind, and human activity are all forces that try to move soil. Stable soil stays in place. That makes it a good habitat for bacteria, fungi, plants, and animals.

What makes stable soil? Stable soils usually have lots of organic matter. They also have healthy communities of bacteria, fungi, and animals.

1. Get a clear container that is at least 10–15 cm tall. The opening to the container should be large enough to find your hand.
2. Get some wire mesh with large openings. Chicken wire is a good example.
3. Use a tool to dig up some soil in your research area.
4. Gently separate the soil. Allow it to fall apart into clumps.
5. Choose a clump of soil about 3–5 cm across.
6. Let the soil dry for 48 hours in a warm place.
7. Fill your clear container with water.

8. Bend a piece of wire mesh so that it forms a basket inside the clear container. Place the basket so that it sits under the water.
9. Gently place your soil in the mesh basket.
10. Start a timer.
11. Watch to see how long it takes the soil to break up and fall apart through the wire mesh.
12. Soil that falls apart in less than 1 minute is not stable. Soil that falls apart between 1 and 5 minutes is stable. Soil that falls apart after 5 minutes is very stable.
13. If the soil is not stable, notice how the soil in that area is being used. Is this a space that people are also using? If so, how are they using it?

6. Some tests are more complicated. For example, you might want to know if your soil is polluted. That information needs a special test. You can send a sample of your soil to be tested by a professional. This usually costs money. These tests are usually done by the local government, a university, or a private laboratory. You can also purchase some kinds of tests to do yourself. They use special chemicals that you can't find on your own.
7. Remember the questions from the Task 2, Understand activity. Work with your team to try to answer these questions if you have not already:
    i. Organic Matter:
        1. Is there organic matter in your research area?
        2. When plants and animals die, do people remove them or can they decompose in the soil? For example, when a tree dies or falls over, is it cut up and taken away?
    ii. Water:
        1. When it rains does the water quickly run off the surface of the soil without absorbing? Or does some of it absorb into the soil?
        2. Is there any pollution in your research area that could absorb into the soil?

iii. Space:

1. How much of your research area has soil?
2. Are there any spaces in your research area where something is covering the soil, such as pavement or a building?
3. Does the soil look like it has been disturbed? If so, who or what is disturbing it?
4. Are there any soil organisms in your research area that people do not like or are trying to get rid of? What do they do or use to try to get rid of those organisms?

8. Decide how you want to record the information from your investigations. You can write it down, draw pictures, record your voice, or find another way.
9. Work by yourself to conduct your investigation.
10. Read what Christine says about investigating conflicts in her research area.

Christine says . . .

My research group is interested in the way we use the land and how land management efavfects soil organisms. We are also interested in how climate change impacts soil organisms.

In terms of land use, we study all the different ways that farmers manage their crops and their land. One of my students is looking at a tilled system, where the farmer uses a plow, and a system where there is no tillage. What we have found is that the soil food web drastically changes based on tillage, which we know disturbs the soil. And when you till, you release a lot of carbon dioxide back into the atmosphere, which then contributes to global climate change.

In terms of global climate change, we want to understand how things like longer droughts and heavy rainfall events influence soil organisms. In the following picture we are under a rainout shelter. The rainout shelter is keeping all the rain out for an entire growing season so we can study how drought impacts a field of crops. We are studying how nematodes respond to this stress.

Figure 6.8: Christine and a member of her team collect data under a rainout shelter.

Act: *What do we think about the conflicts in our research area?*

Your team has investigated how soil organisms in your research area might have problems meeting their needs. Now, your team will share what you observed and think about how people may be involved in these conflicts.

1. Take out the observations you recorded from the Understand activity.
2. Take out your *Part 6 Organizer*.
3. Have the team leader record what they found out in the Understand activity. They should put their answer in the *Know* column. For example, the team leader may have observed walking paths in your research area that help people get from one place to another. But the soil under this path is compacted. The soil also has low biodiversity.
4. If the team leader shares any conflicts that you also found in your investigation, let them know. Circle that need or make some other mark. This will help you record that this is something that is a conflict for more than one soil organism.

5. Next, share the conflicts you learned about in the investigation that haven't already been listed. Have the team leader record your observations or add them yourself if you are working with a digital or shared document.
6. You should now have a list of the conflicts in your research area.
7. Take out your *Part 3 Organizer*. The *Know* column has information about what the people in your community need.
8. As a team, compare the information in the *Know* column of your *Part 3 Organizer* to the information in the *Know* column of your *Part 6 Organizer*.
9. Discuss the following question as a team:
    a. Consider the needs of the people in your community. Remember that you recorded this information in your *Part 3 Organizer*. Do you think any of these needs are causing the conflicts between people and soil organisms?
10. Record your answers in the *Think* column of your *Part 6 Organizer*.

Task 4: What are people already doing to balance the needs of people and soil organisms?

In this task you will ***discover*** how you think and feel about conflicts between people and soil organisms in your research area. Then you will use information from your community and your research mentor to ***understand*** how people are already working to solve these conflicts. You will ***act*** to think about what you would do about the conflicts in your community.

Discover: *What is my perspective on the conflicts in my research area?*

In Task 3 your team identified the conflicts between people and soil organisms in your community. There can be many perspectives on conflicts. You probably have your own thoughts and feelings. Other people might have other ideas and perspectives.

1. Consider what your team wrote in the *Know* column of the *Part 6 Organizer*.
2. Think quietly to yourself about the following questions:
    a. How do the conflicts between people and soil organisms in your research area make you feel?
    b. Which conflicts are most important to you?
    c. Think back to your answer from Task 1 about whether or not soil is important to you. Did your opinion change?
    d. Which conflicts do you think will be the hardest to solve?
    e. Which conflicts do you think you are able to take action on?
3. Take out or remember your identity map from Part 1. How do you think your identity affects how you think and feel about the conflicts in your research area?
4. Pair with a teammate.
5. Ask your teammate the same questions from Step 2.
6. Think quietly to yourself about the following questions:
    a. How are your answers similar to your teammate's answers?
    b. How are they different?
    c. Have you changed your mind about any of your answers?

7. Remember the four perspectives you learned about in Part 1, Task 3. The following situations involve at least one of those perspectives. Read each situation and identify the conflict in each one. Then, discuss with a teammate how each conflict makes you feel. Which perspective is most important to you? What do you think you would choose to do about each conflict?
   a. Economic and environmental: A storm knocks down several large trees in a community. The trees can be cut up and sold by the community as fuel or building materials. But the dead trees will also provide important habitat for fungi, bacteria, and animals such as insects. It will also provide organic matter to the organisms living in the soil.
   b. Social, ethical, and environmental: A community hires a developer to add paths to a community park. The new paths will allow people to move to parts of the park they couldn't get to before. The developers say that the cheapest and safest option is to make the paths out of concrete. The paths will be wide and flat, which will allow people to walk, run, ride bikes, use strollers, and any other mobility tools such as wheelchairs, walkers, and canes. A group of people ask the developer to use gravel instead. Gravel will allow rainwater and organic material to filter down into the soil. This will help keep the soil organisms in the park healthy. But gravel pathways cannot be used by everyone.

> **⚠ Emotional Safety Tip**
>
> You may have a strong opinion about some of these statements. Remember to be respectful in how you share your thoughts and how you listen to others. It is okay to disagree but remember to disagree with ideas and not people.

8. Read what Christine says about considering perspectives.

Christine says . . .

We live in a global environment where everyone has different needs. We all rely on the soil for food. But some people rely on it for income as well. I work a lot with farmers who rely on soil to grow food and foresters who rely on soil to grow trees for timber. There is tension and conflict when it comes to finding

that balance. How do we take enough from the land to support families and a business and have an income, but also think about the environment and do this in a sustainable way?

There are social and ethical components to this. Who decides what people can do with their own land? We can't all be selfish, especially with global climate change.

It's important to think about all of these perspectives. It is important to have conversations with people. I interview farmers as part of my research. Farmers always tell me, "I get my water from Lake Erie just like you do. I want to make sure that I manage my farm properly so it doesn't pollute the lake." I think when we see what we have in common and understand that we all share these natural resources, we can find some common ground. We can find the best management that helps people earn money but also protects the environment.

Understand: *How can we find out more about solving conflicts?*

As you learned in Part 3, there are some people who think about the conflicts between people and other living things because it is important to their way of life or it is their job. These people think about and try to solve the same kinds of problems you are trying to solve in this guide. These can be difficult problems to solve!

In this activity, you will think about just one conflict in your research area. You will try to find out what people in your community are already doing about this problem. You will learn more from your research mentor. This will help you create solutions that are sustainable and inclusive.

1. You can work on this activity by yourself or with the teammate you worked with in the Discover activity.
2. Remember which conflicts felt most important to you in the Discover activity.
3. Choose one of those conflicts to learn more about.
4. By yourself, record what the soil organism(s) in that conflict need. Remember that you can find that information in your *Part 6 Organizer*.

5. Next, record what the people in that conflict need. Remember that you can find that information in your *Part 3 Organizer* or your *Part 6 Organizer*.
6. Finally, record how the needs of soil organisms and people cause or contribute to this conflict.
7. For example, maybe your research area has a garden or a farm. This farm grows the same kinds of plants every year. When it is not the growing season all the dead plants are cleared away. The soil is tilled. This causes a conflict between people and soil organisms. You would record:
    a. What the soil organisms need: The soil organisms need a source of energy from organic matter. They need space in the soil to live. They need that space to be undisturbed.
    b. What the people need: The people depend on the plants for food. They also sell some of the plants to make money.
    c. What causes the conflict: The garden helps people meet their needs but it is harming soil organisms. The tilling disturbs the soil organisms. The organic matter is cleared away after the growing season which means the soil organisms do not have a source of energy.
8. Decide if you need more information about this conflict from your research area or community. You can do another investigation in your research area or community to find out more about what the soil organisms or people in this conflict need. If you feel you need more information, gather it now.

Act: *How can I take action on conflicts in my community?*

Now that you have learned more about the conflict you chose, you are going to think about what you would need in order to take action. This information will help your team complete Task 5.

1. You can work on this activity by yourself or with the teammate you worked with in the Discover and Understand activities.
2. Think about the conflict that you learned more about in the Understand activity.

3. Answer the following questions by yourself or with your teammate:
    a. What would you do to try to solve this conflict?
    b. Who would your solution help? People? Soil organisms? Both?
    c. Which group's needs are most important to you? Why?
4. Take out your *Part 2 Organizer*.
5. Consider the information in the *Know* column.
6. Answer the following questions by yourself or with your teammate:
    d. Who makes decisions in your community?
    e. Who are the people in your community who don't usually get to share their ideas or help with decisions?
    f. How can we make sure those people are included?
    g. How can we find out what people are already doing to solve conflicts between people and soil organisms in our community?
7. Read what Christine says about how people can take action to keep soils healthy.

Christine says . . .

Rather than growing corn over and over on a farm, you could rotate crops. And it's important to have something covering the soil all year. Have plants that cover the ground in the winter. They may not be a crop that you can eat, but they will stop the soil from being blown or washed away. Some kinds of crops can also help return nutrients to the soil.

It's really important to think about what you are "feeding" the soil and how you are treating the soil. Rather than tilling, you use a practice that disturbs the soil less. Reduce the amount that you are tilling or stop tilling altogether.

Most of our agriculture is annual plants that grow and die within 1 year, like corn. Think about planting other crops that help put nutrients back into the soil.

8. Read what Christine says about why it's important to include the community when taking action.

Christine says . . .

It is important to work with the community, especially when working with soils and producing food. Food is a very personal part of our lives. For so long there have been communities that have either been stopped from being able to grow their own food or have not had access to land.

That's what I love about the urban garden and local food movement. It empowers people to grow food in areas where they've never been able to have a garden before. Producing food is such a basic component of everyday life. Everyone should be able to have access to food. If you can grow it safely on your own, that's really important. Healthy soil is an environmental justice issue.

Figure 6.9: This group of people has changed an empty lot into a community garden, which allows the people to grow their own food.

Task 5: How can I take action to balance needs in my community?

Change happens on different levels. There are things you can change about your own behavior. There are also changes that happen within the whole community. In this task you will ***discover*** what you know about changes needed for your community. Your team will use this information to decide on your community action plan in Part 7. You will also ***understand*** some ways you can personally change your behavior to help your community. Then you will ***act*** on those ideas.

Discover: *How is our community meeting the needs of people and soil organisms?*

In any community there are people and other soil organisms trying to meet their needs. Sometimes these needs cause conflict. Now you will use what you have learned in this Part to think about ways you could make those conflicts better.

1. Take out your *Part 6 Organizer*.
2. Your team has already listed information you found out from your investigations in the *Know* column. Add any additional information you want to remember.
3. Now you will list or draw everything your team thinks about your community under the *Think* column. Consider:
    a. Think about the work you did in Task 4. What do we think are the most important conflicts to solve between people and soil organisms in our community?
    b. What do we think are some good ways to try to solve those conflicts?
    c. Do we think our community could do better at meeting the needs of soil organisms?
4. Take out your Balanced Community Goals. Compare them to the things you *Know* and *Think*. Your Balanced Community Goals show you how your team wants your community to be. What you *Know* and *Think* shows you how your community is. When your community is not the way you want it to be, that is a problem.

5. As a team discuss:
    a. How well do you think your community is meeting the needs of the soil organisms in your research area?
    b. Are there goals in the *Balanced Community Goals* that would help your community meet the needs of soil organisms? If not, think about adding those goals now.
    c. Do you think it is important to meet the needs of soil organisms? Why or why not?
    d. Record these thoughts in your *Think* column.
6. Think back to the investigations you did in Part 2, Task 3, Understand about who makes decisions in your community. Think about how people your age are involved in making decisions.
    a. Which conflicts do you think you could take action on?
    b. Which conflicts would you need help with?
    c. Record those now in your *Think* column.
7. List or draw everything your team still wonders about your community under the *Wonder* column. Consider:
    a. Are there questions you still have about how your community meets the needs of people and soil organisms?
    b. Are there actions you could take that might help your community balance the needs of people and soil organisms?
8. Keep the *Part 6 Organizer* safe. You will need it again.

Understand: *How can I solve conflicts?*

In this Part you investigated how the soil organisms in your research area meet their needs. You also learned how the people in your community meet their needs and wants. You noticed how those needs might cause conflicts. You thought about ways that your community could better balance the needs of people and soil organisms. You will have a chance to put some of these ideas into action in Part 7. However, there are always ways that you could make things in your community better through your own individual actions.

1. Consider the *Think* and *Wonder* sections of your *Part 6 Organizer*. Are there any problems that you could help to change all on your own? Are there any actions you could take on your own?
2. Discuss your ideas with your team. For example:
    a. Suggest any of your ideas about reducing conflict from Task 4.
    b. Help people in your community become more aware of soil and the soil organisms around them. You could do an art project by painting with soils. Or you could do one of the investigations from this Part as a community activity.
    c. You could make choices about the things that you buy or do that reduce the amount of plastic waste or pollution coming from your household.
    d. You could think of ways to add more organic matter to the soil in your community. You could compost your food waste and add it to the soil near your household. Or you could ask people to let dead plants break down on their property so those nutrients go back to the soil.
    e. You could work with the people in your household to make a list of your needs and wants. Then, you all could think about which needs and wants might make it difficult for soil organisms to meet their needs. Are there any things that you need or want that you could use less of?
    f. Come up with your own ideas.

Figure 6.10: This sign at the Smithsonian's Mary Livingston Ripley Garden encourages visitors to leave their yards, gardens, and green spaces messy. Leaf litter, piles of sticks, and other kinds of organic matter can help insects survive cold weather and gives birds materials to build their nests. The Smithsonian Gardens team has left plenty of this material in the large structure in the background.

3. Read some examples of action from your research mentor Christine.

Christine says . . .

Talk to the older generation about climate change. A lot of times climate change seems so abstract, and people say, "Oh, it's only impacting people in that other place, it's not affecting me here." But scientists are observing that climate change is impacting everyone, all ecosystems, all regions. We all have an individual responsibility to do something about it. A great step is just talking to people about it and explaining even little things they can do to help. For example, if you convert a lawn into a pollinator garden you can help increase insect biodiversity. But a side benefit is that you are keeping carbon in the soil instead of the atmosphere, and you are making the soil healthier.

Plastic waste is also a huge problem for soil, so can you take reusable bags to the grocery store? Can you compost instead of throwing away your food waste? Composting is a great way to immerse yourself in the process of soil and making soil. You can watch your food waste turn into soil. That's a really fun and active way for people to get involved in soils.

You can even grow your own food in a tiny little garden. Even if it's just a couple of tomatoes and carrots, that's less food that had to be transported from a farm.

4. Think quietly to yourself about a change you want to make in the way you act. Why do you think this change is important?

Act: *How can we take action and reflect?*

Changing our own behavior is often the first step. Now that you have decided what you will do to improve your community, you need to put that idea into action.

1. Make a plan for how you will put your idea into action. If you need to share information, where, when, and with whom will you share it. If you need to do something, what do you need to do it.

2. Put your plan into action.
3. Quietly reflect on your action by yourself:
    a. What seemed to go well?
    b. What was hard?
    c. Were you able to make the changes you thought you would be able to make?
    d. Will you keep going with your change or are there things you would do differently in the future?

Congratulations!

You have finished Part 6.

Find out More!

For additional resources and activities, please visit the *Biodiversity!* StoryMap at https://bit.ly/3zvJ2Qh.

Glossary

This glossary can help you understand words you may not know. Feel free to add drawings, your own definition, or anything else that will help. Add other words to the glossary if you would like.

Arthropod: A kind of animal without a backbone that has a segmented body, exoskeleton and paired appendages

Berlese funnel: A tool that captures the animals living in soil and leaf litter

Classify: To find the name of something or put it in a category

Climate change: Changes in the patterns of temperature and precipitation on Earth

Compacted: Closely packed together

Decomposing: The process of breaking down or breaking apart

Dichotomous key: A tool that helps identify living things by choosing between two characteristics

Ecosystem: A community made of living things and nonliving things

Estimate: A guess at the size or number of something

Field guide: A collection of descriptions and images that help the user identify living things

Growth plate: A plate filled with nutrients on which bacteria and fungi can grow

Litter: The layer of organic matter that sits above soil

Nematode: A small worm that lives in soil

Organic matter: The living, dead, and decomposing material in the soil

Sediment: The soil-like material that lines the bottom of a body of water

Soil: The mix of minerals, air, water, and living things that sits on Earth's surface

Soil health: The ability of soil to support the growth of plants, animals, and bacteria.

Stable: Not likely to move or change

Till: To dig into soil and turn that layer over on itself

Trowel: A tool with a flat blade that can be used to dig into soil

Other words:

