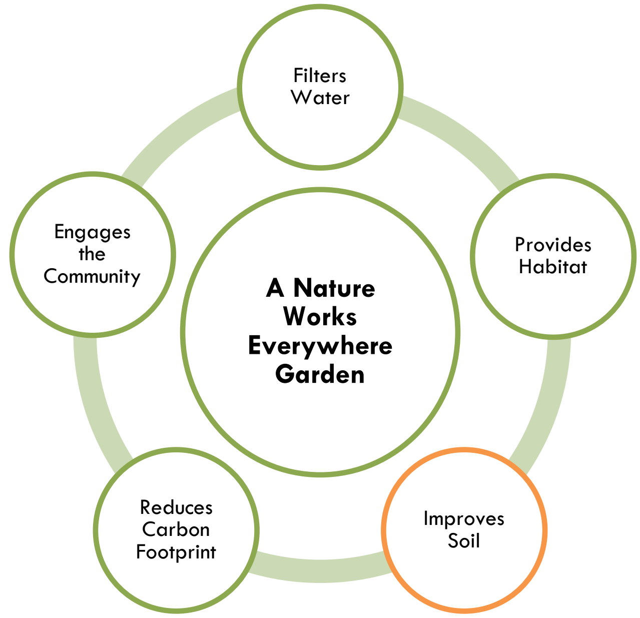
GARDEN LESSON PLAN: SOIL



Many elements are interconnected and function together to create the natural and productive living system that is your garden. Look to the end of this activity guide for additional lesson plans, activity guides, and videos that can help you bring together soil, water, habitat, food, and community to explore your dynamic garden ecosystem.

Subject Area: Gardens, General Science

Grade Levels: Geared toward 6th-8th grade, but can be tailored for all grades

Essential Question:

How does a garden help to produce healthy soil?

Purpose and Overview:

In this set of activities, students conduct a soil analysis to understand soil types and explore the relationship between the garden and healthy, fertile soil. Soil is a natural resource that is crucial to life on Earth. When managed properly, it supports a healthy soil food chain that is the basis for maintaining a functioning habitat that, in turn, makes the garden productive.

This activity guide is part of an extended learning experience that engages students in creating and maintaining a school garden and is an extension of the *How Dirt Works* lesson plan, found at https://www.natureworkseverywhere.org/resources/how-dirt-works/.

In this lesson, students review the components of soil before completing soil analysis tests on school garden soil to determine soil texture and assess soil fertility. By completing soil sampling activities, students will have a better understanding of how these factors contribute to the overall health and productivity of the garden.

The lesson is designed to be completed on an "off" day for irrigation (watering) of the garden, when the soil is dry and there has been no significant precipitation for at least two to three days. Ideally, you should complete the activity before planting in order to address any soil deficiencies that may need correction, but soil amendments can be made in any garden. NOTE: Always have your garden's soil tested for any toxins before allowing students to work with the soil. Contact your state Agricultural Experiment Station or Extension Agency for information about soil testing.

Time:

This lesson is part of an extended learning experience that engages students in creating and maintaining a school garden.

- Engage: one 45-minute introductory lesson.
- Explore: two 45-minute analysis activities completed over two days.
- Explain: one 45-minute class period.
- Extend: Allow one to two 45-minute sessions for the suggested lessons.

Materials and Resources:

Nature Works Everywhere videos supporting this activity guide:

- How Dirt Works - https://vimeo.com/77792712
- Global Gardens - https://vimeo.com/77792707

Nature Works Gardens How-to Video Series:

- Planning Your Garden - https://vimeo.com/91446626
- Building a Garden in a Day - https://vimeo.com/91445078
- Caring for Your Garden - https://vimeo.com/92520693
- Fears - https://vimeo.com/92531513

Materials for teacher

- Computer with Internet connection
- An apple and paring knife (optional)
- Samples of potting soil or potting mix and garden soil

Materials for each student or group of students

- Garden Projects notebook
- 1-quart glass jar, such as a Mason jar, with tight-fitting lid
- Masking tape (to label the jars)
- Digging tools such as a trowel or large spoon
- Rulers
- Water
- Wire coat hanger (for soil test)
- Handouts listed below can be found here: https://www.natureworkseverywhere.org/resources/activity-guide-soil/
    a. Soil Analysis Field Report
    b. Soil Colors
    c. Soil Evaluation
    d. Soil Texture

Objectives:

The student will…

Knowledge
- State reasons why it is important to identify soil type and fertility of a garden.

Comprehension
- Explain the difference between soil and dirt.
- Discuss the components of soil.
- Distinguish between soil particle size for sand, silt, and clay.
- Discuss where plants get the nutrients they need in order to grow.
- Explain how garden productivity can lead to healthy soil

Application
- Conduct an experiment to analyze soil composition.
- Conduct an experiment to analyze soil fertility.

Analysis
- Analyze soil tests to determine the soil type and fertility of school garden soil.

Synthesis
- Construct an argument to show the importance of soil as a natural resource.
- Explain the impact of different soil types on a plant's need for air and water.

Evaluation
- Define concepts such as soil, soil composition, soil fertility, and weathering.

Next Generation Science Standards:

Disciplinary Core Ideas:

- LS1.B Growth and Development of Organisms
- LS2.A Interdependent Relationships in Ecosystems
- LS2.B Cycle of Matter and Energy Transfer in Ecosystems
- ESS2.A Earth's Materials and Systems
- ESS2.C The Role of Water in Earth's Surface Processes
- ESS3.A Natural Resources

Crosscutting Concepts:

- Cause and Effect
- Patterns
- Energy and Matter
- Stability and Change

Science and Engineering Practices:

- Developing and Using Models
- Constructing Explanations and Designing Solutions

Performance Expectations:

Middle School

- LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
- LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

- LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
- ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
- ESS3-1 Construct a scientific explanation based on evidence for the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geo-science processes.

Common Core Standards:

6th-8th Grade Science and Technical Subjects

- CCSS.ELA-Literacy.RST.6-8.3 Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks.

Vocabulary:

Amendments/Soil amendments: Nutrient-rich materials such as compost, peat moss, bone meal, etc., that are added to the soil to improve its composition and productivity.

Autotroph: An organism that produces its food from chemical substances. See *heterotroph*.

Compost: A mixture of decayed plants used to fertilize and improve garden soil.

Decomposition: The natural process of decay whereby dead plants and animals slowly break down into organic matter.

Heterotroph: An organism that feeds on organic matter such as plants and other organisms. See *autotroph*.

Humus: The organic matter component of soil made up of decayed plants and animals.

Loam: A soil texture consisting of approximately 40% sand, 40% silt, and 20% clay, that is preferred for farming and gardening.

Micro-organisms: Microscopic organisms including fungi and bacteria.

Organic matter: The part of soil made up of the decomposed remains of once-living plants or animal bodies.

Soil: Complex mixtures of minerals, organic matter, air, and water that support plant life on Earth and are, therefore, crucial to all life on the planet.

Soil composition: The makeup of a soil according to the proportions of its four basic components: minerals, organic matter, air, and water.

Soil texture: An indicator of the nutrient and water holding capacities of soil that is determined by the proportion of sand, silt, and clay soil particles.

Soil fertility: The capacity of soil to be productive in sustaining and growing plants.

Soil particles: The mineral component of soil. Soil particles are classified into three sizes — sand (2mm-0.05mm), silt (0.05mm-0.002mm), and clay (<0.002mm).

Weathering: A process that occurs as rocks are broken down into smaller and smaller pieces by the effects of physical, chemical, and biotic forces.

Engage

Please refer to the *How Dirt Works* (https://www.natureworkseverywhere.org/resources/how-dirt-works/) lesson plan for a full set of activities and suggested learning topics to engage your students around the topic of soil. The lesson plan teaches students how soils help to regulate water, sustain plant and animal life, filter pollutants, cycle nutrients, and support structures. In addition to soil texture and composition tests below, the lesson plan provides activities to assess soil compaction.

1. Begin by viewing the *How Dirt Works* video (https://vimeo.com/77792712 - 4.5 minutes). At the end of the video, ask students "What is soil and why is it important?" Challenge your students to name a product (food, materials, and any objects you see in the classroom) that was not produced or somehow supported by soil.

2. Use an apple to show students how important it is to protect the Earth's soils. You can view a video of this demonstration here: https://www.youtube.com/watch?v=mA78nPn41F4. Tell students that the apple represents planet Earth.

    a. Cut out a quarter of the apple and set the rest aside, explaining that about 75% of our planet is covered with water. The quarter section remaining represents all the dry land on Earth.
    b. Ask students, "How much of this dry land do you think is covered by productive soil, like the kind we saw in the video?"
    c. Tell students that about half the dry land on Earth is desert, mountain, or covered by ice — too hot, too high, or too cold to be productive.
    d. Cut the quarter section of the apple in half and set half aside; the remaining section now represents all the productive soil on Earth — only about 12.5% of the Earth's surface.
    e. Remind students of the statement by Sophie Parker, Ecoregional Ecologist for The Nature Conservancy in California, that "without soil we would not have life on Earth" (at 0:30 in the video).
    f. Peel the skin off the remaining apple section and explain that it represents the soil she was talking about. Have students pass this fragment of apple skin around class to demonstrate how productive soil (soil we can use for the world's food supply) is a limited resource.

3. **Note: the remainder of this learning session can be conducted outside in your garden.** Show students samples of potting soil and garden soil (from your garden). Have students examine the two samples and discuss their observations. Students should recognize that the garden soil contains lots of mineral particles — tiny pieces of rock — in addition to bits of organic matter, whereas the potting soil is almost entirely organic matter. Explain that the potting soil has been manufactured for growing plants in containers. It's a mixture, made up mostly of decayed plants, that has been heated (sterilized) to kill any micro-organisms, along with some air and water. The garden soil is full of micro-organisms — as students saw in the video (at 1:25-2:05) — and consists mostly of mineral particles mixed with organic matter, air, and water. Ask students what they think are the benefits of garden soil vs. potting soil. What are the drawbacks? How do they think the garden soil may be better for productivity?

4. Review with students how each of the components of garden soil (organic matter, water, minerals and air) factors into the formation of soil.
    a. **Mineral particles** are produced by the weathering of rock. These weathering processes include atmospheric conditions like rain, wind, heat, freezing, etc.; chemical reactions such as oxidation and carbonation; and biotic activity such as the growth of plant roots and the presence of micro-organisms, algae, and fungi. Mineral particles make up approximately 45% of a typical soil.
    b. **Organic matter** consists of once-living organisms — plants and animals — that have undergone the process of decomposition. Organic matter, also called *humus*, makes up only about 5% of typical soil and is found primarily in the soil's top layer.
    c. **Air and water** fill the spaces between mineral particles and enter soil from the atmosphere. These two components have a reciprocal relationship: in drier conditions, there is more air in the soil; in wetter conditions, more water. Together, air and water make up approximately 50% of a typical soil.

5. Remind students that, as they learned in the video (at 3:00-3:15), it can take millennia for these ingredients to come together as soil. In fact, it takes nature approximately 500 years to form just one inch of topsoil. That means the top layer of soil in your garden started forming not long after Columbus landed in North America.

6. Ask students which of the ingredients in soil are important for healthy plant growth. They should already know that plants need the water in soil for photosynthesis. They may not realize, however, that — just like people — plants need calcium, potassium, iron, zinc, and other nutrients, which their roots absorb from mineral particles in the soil. Plants also need phosphorus and sulfur, which come from the organic matter in soil, and nitrogen, which is produced by bacteria and other micro-organisms that live in this organic matter. And plants need the air spaces in soil for root growth. In other words, plants need all the components of soil for healthy growth.

7. Explain that plants are *autotrophs* — organisms that produce food for themselves from chemical substances. When these substances are not available, plants can't survive. And without plants, most *heterotrophs*, like us — organisms that feed on organic matter — wouldn't be able to survive either.

8. Conclude this section by telling students that they will be analyzing the soil in their garden to find out if it is providing what plants need for healthy growth.

Explore

Distribute copies of the Soil Analysis Field Report student handout for students to record data. Alternatively, you can have students create versions of the soil analysis handout in a garden journal or notebook. Explain that students will complete two soil analysis activities to learn more about the health of their garden soil, one for soil texture and another for soil fertility.

Optional – Before heading outdoors, you may want to give students a preview of soil texture analysis by viewing the YouTube video at https://www.youtube.com/watch?v=knrmCbctGEA, which provides additional background on the purpose of the soil texture test and demonstrates the process in a lab setting.

Part 1: Soil Texture Analysis

In this activity, students analyze the mineral component of their soil to determine its proportion of *sand*, *silt*, and *clay*. In soil science, these terms are not simply descriptive — they refer specifically to different size mineral particles:

a. **Sand** particles are the largest, measuring 2.0mm-0.05mm in diameter, are easily visible with the naked eye, and feel gritty to the touch. Soils made entirely of sand particles allow water to move freely, creating well-drained, well-aerated, often-times drier areas.

b. **Silt** particles measure 0.05mm-0.002mm in diameter. Only the largest of these particles are visible and feel smooth like talcum powder or flour to the touch. With medium-sized particles come medium-sized spaces for water and air. Silty soils hold more water than sandy soils but have fewer adhesive properties than clay soils. Silty soil also holds minerals well, making them an important part of productive soil.

c. **Clay** particles are the smallest, <0.002mm in diameter, are not discernible to the eye as individual particles, feel gritty and hard when dry, but sticky and plastic when wet. With such fine textures, water is captured and held for long periods of time, creating very wet conditions that subject the soil (and plants) to damage. However, since the clay particles have a large surface area relative to their volume, they are highly reactive and able to attract and hold nutrients. A purely clay soil is not ideal for planting, but clay is an important part of the make-up of productive soil.

   For visual help and context, you can explain the particle sizes this way: If you were to enlarge these particles to the point that the grain of sand was now the size of a basketball, the silt would be about the size of a golf ball, and the clay would still not be much larger than the head of a pin.

   Most plants grow best in soil that is approximately 40% sand, 40% silt, and 20% clay. This type of soil is called *loam* and serves as a benchmark for soil texture analysis. When the proportions of sand, silt, and clay depart significantly from this balance, the soil may not function properly for plant growth.

1. Ask students to discuss the questions below. Answers are in red. Share the information below with students and discuss how an imbalance between these three types of particles could affect the health of plants.

- What if there is too much sand? (Water will drain through the soil too quickly for the plants' roots to absorb it, and there will be a deficiency of nutrients in the soil.)

- What if there is too much clay? (Water will be trapped in the soil, threatening some organisms, like earthworms, that produce nutrients from organic matter and need air to live underground.)

- What if there is too much silt? (Plants will probably have enough water and nutrients to survive but may not thrive.)

- Also discuss how different plants like different types of soils – some plants that prefer well-drained soils thrive in sandy soil, while plants that require more water will do better in soils that retain water.

2. Have students work in pairs for this activity. Provide each pair with a soil sample collection jar and have them label their jar using a piece of masking tape. Assign each pair to a different location, so that you can compare data for all parts of your garden. Provide students with appropriate digging tools and rulers, and then direct them to follow the directions on the Field Report sheet.

3. Students will be able to measure the amount of sand in your soil within a few minutes, but it can take several hours for the silt to settle, so provide space for students to store their jars overnight and complete this activity the following day.

4. When students have completed their analyses, compare the results from different parts of your garden. Is the soil texture consistent everywhere? Are there areas where the proportions of sand, silt, and clay are close to those for loam? Are there areas where the proportions depart significantly from loam? If so, and if you have an existing garden, how are these differences reflected in the health of your plants?

5. Point out to students that the material floating at the top of their sample collection jars is organic matter in the soil. Remind them that organic matter makes up only about 5% of a typical soil and have them measure the organic matter in their samples to determine (roughly) the proportion of organic matter in your soil. If appropriate, discuss how excessive organic matter could affect the soil and the health of your plants. For example: excessive organic matter increases the amount of nitrogen in the soil, which may spur rapid vegetative growth at the expense of reproductive growth, reducing fruit and vegetable production; it also increases the amount of phosphorus in the soil, which can wash from the garden into the watershed as "nutrient pollution," spurring algae growth in lakes and waterways that reduces the amount of dissolved oxygen available to fish and other organisms in these ecosystems.

6. To conclude this activity, introduce students to the Soil Texture Calculator at the U. S. Department of Agriculture's Natural Resource Conservation Service website (https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/research/guide/?cid=NRCS142P2_054167). Have them enter the rough percentages of sand and clay for their samples in the appropriate boxes (the calculator deduces the percentage of silt from these two numbers) and then click the "Get Type" button. (Note: The calculator is designed to work with percentages by weight rather than percentages by volume, which is what your students have

measured. You can correct for this discrepancy, if you wish, by multiplying their sand percentage by 1.19, the silt percentage by 0.87, and their clay percentage by 0.94. These are the weight ratios of bulk density compared to average bulk density for each material.) The calculator not only displays the type name for soil with this proportion of sand, silt, and clay but also (scrolling down) shows where this soil type falls within the soil texture triangle, making it easy to see how much any soil differs from loam.

(Optional) To give students a more complete visual of their soil texture, distribute copies of the Soil Texture student handout (https://www.natureworkseverywhere.org/resources/activity-guide-soil/). Have students color in the triangles based on the percentages in each of their soil samples.

Part 2: Soil Fertility Analysis

In this activity, students conduct a sensory analysis of their soil using the kinds of techniques that farmers relied on to judge soil fertility during the millennia before there were soil testing laboratories (and still sometimes used today). Students fill out a soil assessment form similar to the Soil Health Cards developed by the USDA Natural Resources Conservation Service in cooperation with several state agricultural agencies. To find out if a Soil Health Card is available for your state visit:
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/health/assessment/?cid=nrcs142p2_053871

1. Plan this activity for a day when your garden soil is moist, approximately two days after a soaking rainfall or after you have watered the garden. Review the introduction at the top of the Field Report sheet, asking students to explain the term *fertile* if necessary, and then review the activity directions. Have students complete the activity in pairs, providing each pair with a wire coat hanger, and assign them to different locations so that you can compare data for all parts of your garden.

2. When students have completed their analyses, compare the results from different parts of your garden. Is soil fertility consistent everywhere? Are there areas where the soil provides insufficient air and water for healthy plant growth? Are there areas that appear to lack nutrients? If so, and if you have any existing garden, how are these differences reflected in the health of your plants?

3. Conclude by reviewing the data students have collected on soil color, which is an indicator of the soil's mineral composition, organic matter content, and moisture content.

   For more information on soil colors and soil color testing see:
   - USDA Soil Education https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054286
   - Watch the YouTube videos below produced at Walla Walla Community College
     - Soil Color https://www.youtube.com/watch?v=sluphBL_JpA
     - Matching Soil Color https://www.youtube.com/watch?v=YyzjJYredyk

   Note: Just because a soil's balance of composition, organic matter and moisture content may not be the same ideal balance presented in this activity guide for a garden, different types of soil can still be healthy and productive. For example, soils in deserts or arid areas tend to be quite sandy (recall what we learned earlier about how sandy soil is dry) but the plants native to this soil type grow quite well in and are adapted for that soil type.

Use the following questions to explore this with your students:

- How can soils with different compositions be healthy and productive soils as well?
- Think about sandy soil in the desert – how is this type of soil productive?

Students can use the following guidelines to interpret their observations. A handout of this information is available here for printing: https://www.natureworkseverywhere.org/resources/activity-guide-soil/

Black or dark brown soil is rich in organic matter and usually found in the top 4-5 inches below the soil's surface.

Light brown may indicate that the soil is dry and does not retain water efficiently, especially if you have conducted your tests soon after watering.

Grey or bluish-grey usually indicate that the soil is wet most of the year and does not drain water efficiently. This will reduce the amount of air in the soil, which reduces the oxygen available to organisms that produce nutrients from organic matter and slows oxidation of mineral nutrients like iron and manganese.

Purple or purplish-black soil has a high concentration of manganese, a plant nutrient essential for photosynthesis and root growth.

Orange or red soil has a high concentration of iron oxide — also known as *rust*. Iron oxide forms in soil that is alternately wet and dry and may be a sign that the soil drains water efficiently. Iron oxide also provides plants with iron, another essential nutrient for photosynthesis. In some cases, however, a high concentration of iron oxide may be caused by iron rich rock beneath the soil and indicate a deficiency of other nutrients.

Yellow indicates a high concentration of acidic minerals in the soil, which can reduce the availability of phosphorus, a plant nutrient essential for "fruiting and rooting."

Share this information with students as you review the colors they have observed in your garden soil and discuss how these colors might affect their overall rating of the soil's fertility.

Explain – How does Gardening Improve the Quality of the Soil?

After conducting soil analyses in your garden, your students should have a good understanding of what soil is, how it functions, why it's important, and what the health and productive potential of your garden soil is. In this next section, students will piece together *how* a garden improves the quality of soil and how this is *the* building block of your garden's ecosystem – all life in your garden starts with good soil.

1. Introduce students to the concept of *amending* soil by showing the ***Caring for Your Garden*** How-to video (https://vimeo.com/92520693). By adding natural materials like compost, you will improve the soil's texture and fertility. For more information on how to compost at your school, visit the Environmental Education for Kids website to find directions and materials lists to get you started (http://eekwi.org/earth/recycle/compost2.htm).

2. Using the data students have collected about their garden's soil (or proposed garden space's soil), have students analyze whether the garden's soil should be amended in any way and if so, how. Students can work in small groups to analyze the data together. Then have each group report its conclusions and present an argument for its recommendations. Encourage students to think through the possible consequences of the amendments they may recommend and help them recognize the connections between soil and the many forms of life it supports. Working the soil regularly, amending it gradually, and replacing the organic matter — food and flowers — that you take away each year will keep the garden habitat healthy while allowing the soil to improve and increase productivity over time.

3. To conclude your discussion, remind students of Sophie Parker's statement, in this lesson's introductory video, that productive soils can take millennia to produce and are very difficult to recover if they are lost (at 3:00-3:22). Ask students how, outside of the amendments they are recommending for the soil, the garden itself can improve the soil. What natural processes occurring in the garden will also help the soil? Remember that soil is improved by rich, organic materials which are produced through the process of decomposition.

   As an example of how natural processes improve soil, have students view two short videos in the USDA Natural Resources Conservation Service series, *Unlock the Secrets of the Soil*

   - Soil Stability Test: https://www.youtube.com/watch?v=9_ItEhCrLoQ
   - Benefits of No-Till Farming: https://www.youtube.com/watch?v=RpI09XP_f-w

   Both videos focus on farming and compare soil from a field that has been conventionally tilled and re-planted every year with soil that has been covered year-round with diverse plant life — both crops and grasses. Students will see how, after decades, the constant presence of plant life helps to produce a near ideal soil texture, while the soil that has been traditionally tilled is not as healthy or productive.

Evaluate

Use the Soil Evaluation student handout to evaluate what your students have learned. See the scoring key below.

Scoring Key for Evaluation

1. Given an example of why soil is an important natural resource.
   Possible answers: Soil is essential to life on Earth. Soil cannot be replaced by human efforts. Soil is the foundation for our ecosystem.
2. Identify the four components of soil.
   Mineral particles, organic matter, air, and water.
3. Name one characteristic for each of the different size particles found in soil — sand, silt, and clay.
   Possible answers:
   a. Sand - the largest particle, drains water quickly, provides air space within the soil, and contains few nutrients.
   b. Silt - the mid-size particle, drains water slowly, provides some air space within the soil, and contains nutrients.
   c. Clay - the smallest particle, prevents water from draining, provides very little air space in the soil, and contains many nutrients.
4. Give an example of why it is important to know the texture and fertility of your garden soil.
   Possible answers: Knowing the soil's texture and fertility allows you to assess whether it is functioning productively in the garden. Knowing soil texture and fertility can also help you determine if the soil needs amendment to function more efficiently.
5. Explain how a garden can help to produce healthy soil.
   A garden can help produce healthy soil by supporting the natural cycles of plant growth with the aid of an ecologically informed gardener.

Extend – Further Investigations

Use these additional activities to extend the learning experience, work outdoors with your students, and further investigate your garden, school, and community soil.

1. Connect this lesson to the ***How Natural Areas Filter Water*** Lesson (https://www.natureworkseverywhere.org/resources/how-natural-areas-filter-water/) and the ***Garden Activity Guide for Water*** (https://www.natureworkseverywhere.org/resources/activity-guide-water/) by discussing with students how soil texture contributes to the garden's capacity to filter rainwater and improve water quality throughout the surrounding watershed.

2. Connect this lesson to the ***Garden Activity Guide: Habitat*** (https://www.natureworkseverywhere.org/resources/activity-guide-habitat/) lesson by having students investigate habitats within the garden soil, including micro-habitats that link plants and micro-organisms into symbiotic relationships.

3. Have students apply their soil analysis skills to other sites on your school campus, especially sites where plant life seems distressed. How do soil conditions at these other sites differ from

those in the garden? What might be responsible for the differences? What amendments would students recommend where they find unproductive soil?

4. Add composting to your school gardening project, in preparation for restoring the organic matter you will take from your garden when you harvest its fruits and vegetables. For information on composting, visit the US Composting Council's Composting for Educators site at https://compostingcouncil.org/composting-for-teachers-and-students/. Have students experiment with composting to learn how decomposition depends on organisms that live within the soil.

5. Help students organize a Soil Health Check campaign in your community. Students can take their soil analysis skills to home gardeners, guide them through the Soil Fertility Analysis, get them started on a Soil Texture Analysis, learn how these gardeners have been improving their soil, and compare notes on successes and challenges in the garden.

6. Contact your state's Agricultural Experiment Station or Extension Agency to arrange a class trip during which students would be able to see a sample of their garden soil tested at the station's lab. You can locate your extension office on this website: http://npic.orst.edu/pest/countyext.htm. Students will learn about the level of nitrogen, potassium, phosphorus, and other plant nutrients in the soil, as well as the soil's PH level. Ask if the station uses the Morgan testing method, which yields a spectrum of colors that reflect the presence of all major nutrients and many micronutrients in a soil sample. If a field trip is not possible, invite a soil scientist from the station to visit your garden and talk with students about its soil quality, how the soil might be amended, and the potential environmental impact of some amendments.

7. Broaden your students' perspective on soil with a visit to the Web Soil Survey website (https://websoilsurvey.nrcs.usda.gov/app/), which provides soil maps and in-depth soil data for nearly every county in the United States. Students can enter your school or their home address for information on all aspects of soil quality and soil use in your area. By comparing this data with the results of their own analyses, they may discover that their garden's soil differs significantly from the soil typical of your region. Challenge students to explain this difference, reminding them that a region's soil is produced over vast periods of time through geological, meteorological, and biotic processes, whereas their garden is a cultivated ecosystem that they have created for a specific purpose. If possible, have students build on what they learn at the Web Soil Survey website by analyzing soil samples gathered from parks and other uncultivated sites in your community to compare with the soil in their garden.

8. Students may enjoy learning that every state has an official soil (to go along with the state bird, flower, fruit, etc.). Visit the state soils page at the Smithsonian Institution's *Dig It! The Secrets of Soil* website (http://forces.si.edu/soils/interactive/statesoils/index.html) to learn the story behind each state's official soil and to meet soil scientists from across the country.

9. For a more in-depth look at the underground ecosystem, students can consult the "Soil Biology Primer" at the USDA Natural Resources Conservation Service website (https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/biology/). This online textbook includes illustrated chapters on the soil food web and its impact on soil health, as well as individual chapters on all major soil organisms. You can also download three USDA soil biology classroom activities at

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051607.pdf, including an earthworm farm activity, a decomposition activity, and an activity about what lives in our soil. If possible, have students use magnifiers and microscopes to investigate the organisms living in their garden soil.

Additional Resources

- *How Natural Areas Filter Water*: Students can use this Nature Works Everywhere lesson plan and associated Gardens Activity Guide to explore the connections between soil and water in the garden
https://www.natureworkseverywhere.org/resources/how-natural-areas-filter-water/
https://www.natureworkseverywhere.org/resources/activity-guide-water/

- Growing the Next Generation: educational resources on soil science, land use, watersheds
http://www.growingthenextgeneration.com/programs/

- K-12 Soil Science Teacher Resources: soil education resources from the Soil Science Society of America
https://www.soils4teachers.org/

- Soil-net.com: a soil education site focusing on the United Kingdom
https://www.soil-net.com/

- NASA's Globe Program Soil Teacher's Guide: soil activities including soil characterization, particle density, pH, fertility, soil temperature, and more
https://www.globe.gov/do-globe/globe-teachers-guide/soil-pedosphere

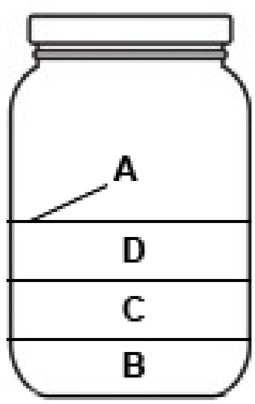
Name:____Date:__________Period:________

Soil Analysis Field Report

Part 1 - Soil Texture

The mineral component of soil is made up of different size particles called sand, silt, and clay. In this test, you will mix soil and water in a jar and then let the soil sink to the bottom so that these different size particles form different layers. By measuring the layers, you will be able to calculate the percentage of sand, silt, and clay in your soil. Follow these steps and record your measurements below.

1. Using a trowel or large spoon, fill your jar about one-third full of soil from 2-3 inches below the surface.
2. Shake the jar gently to level the soil, then measure the soil's depth (A).
3. Fill the jar nearly full of water and then shake it hard to mix the soil and water.
4. Place the jar on a table and wait for the soil to settle.
5. The largest and heaviest particles, called sand, will settle in less than a minute. Measure the depth of sand in the jar (B).
6. The medium-sized particles, called silt, can take hours to settle. Wait a day and then measure the depth of the silt layer (C).
7. The smallest particles, called clay, take even longer to settle, but you can assume that the depth of the clay layer (D) will be equal to the total depth of the soil minus the depth of the sand and silt layers; that is, A - (B + C) = D.



Sample location: ______________________

A. Soil Depth: _______________

D. Clay Layer: _______________

C. Silt Layer: _______________

B. Sand Layer: _______________

8. Now calculate the percentage of sand, silt, and clay using these equations.

   (B ÷ A) x 100 = _____ percent sand   (C ÷ A) x 100 = _____ percent silt

   100 - (percent sand + percent silt) = _____ percent clay

The most productive soil, called *loam*, is approximately 40% sand, 40% silt, and 20% clay. How does your soil compare to loam?

____

____

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____

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Name:____Date:__________Period:________

Soil Analysis Field Report
Part 2 - Soil Fertility

For thousands of years, farmers had to rely on their senses to determine if a soil was *fertile* — that is, whether it would be good for growing healthy crops. Today, most farmers use a soil testing laboratory to determine if their soil is fertile, but you can still learn a lot about soil by using your senses.

Conduct this soil fertility analysis when the soil is moist, about two days after a soaking rainfall or after you've watered the garden. Mark an X in the appropriate box for each soil test, then total the X's at the bottom of the chart. Remember to describe other colors you see in the soil in the space provided.

Soil Tests	Fertile	Average	Infertile
Air and Water			
Can you push a wire coat hanger into the soil?	Goes in easily	Can be pushed in	Coat hanger bends
How does a handful of moist soil feel?	Moist but not muddy	Somewhat dry or muddy	Very dry or very wet
How does the moist soil hold together?	Holds shape but crumbles easily	Breaks apart in clumps	Doesn't hold shape or hard to break up
Nutrients			
What color is the topsoil?	Black, dark brown	Light brown	Grey, yellow
What other colors do you see in the soil?			
How does the soil smell?	Fresh, earthy	No smell or dusty	Sharp, swampy, strange
Can you see organic matter in the soil?	Lots	Some	Not much
Can you see worms and other organisms?	Lots	A few	Almost none
Total (count X's for each column)			

Use the scale below to rate the fertility of your garden soil based on the results of your tests. Mark an X on the appropriate number.

Very Fertile — Not Fertile

10	9	8	7	6	5	4	3	2	1	0

Soil Colors

Black or dark brown soil is rich in organic matter and usually found in the top 4-5 inches below the soil's surface.

Light brown may indicate that the soil is dry and does not retain water efficiently, especially if you have conducted your tests soon after watering.

Grey or bluish-grey usually indicate that the soil is wet most of the year and does not drain water efficiently. This will reduce the amount of air in the soil, which reduces the oxygen available to organisms that produce nutrients from organic matter and slows oxidation of mineral nutrients like iron and manganese.

Purple or purplish-black soil has a high concentration of manganese, a plant nutrient essential for photosynthesis and root growth.

Orange or red soil has a high concentration of iron oxide — also known as *rust*. Iron oxide forms in soil that is alternately wet and dry, and may be a sign that the soil drains water efficiently. Iron oxide also provides plants with iron, another essential nutrient for photosynthesis. In some cases, however, a high concentration of iron oxide may be caused by iron rich rock beneath the soil and indicate a deficiency of other nutrients.

Yellow indicates a high concentration of acidic minerals in the soil, which can reduce the availability of phosphorus, a plant nutrient essential for "fruiting and rooting."

Name:____Date:________________________Period:_____

Soil Texture

Directions: Color the graphics below based on the percentages of soil types in each of the samples you collected.

Sample 1

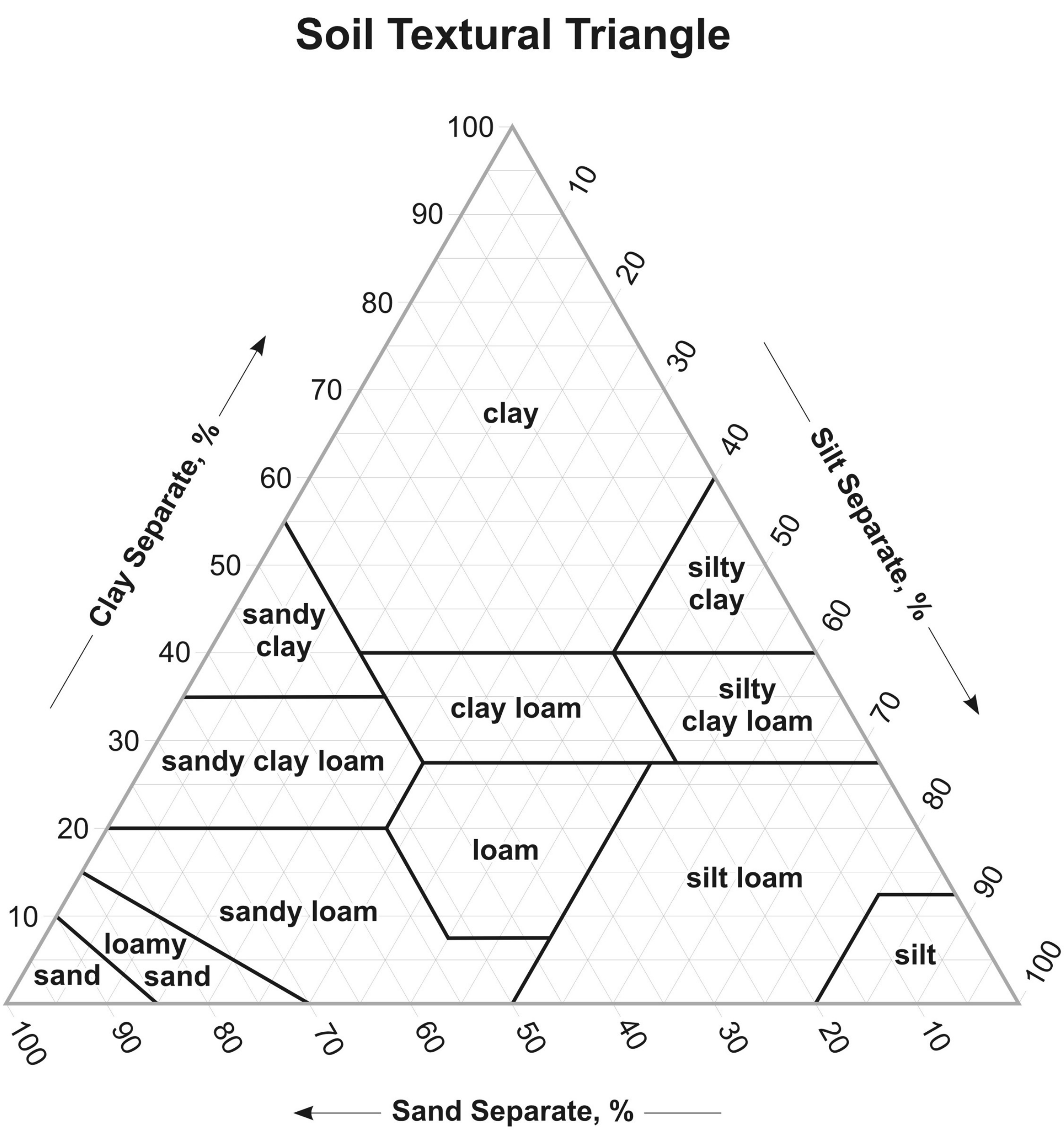

Image credit: USDA Natural Resources Conservation Service
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054311

Sample 2

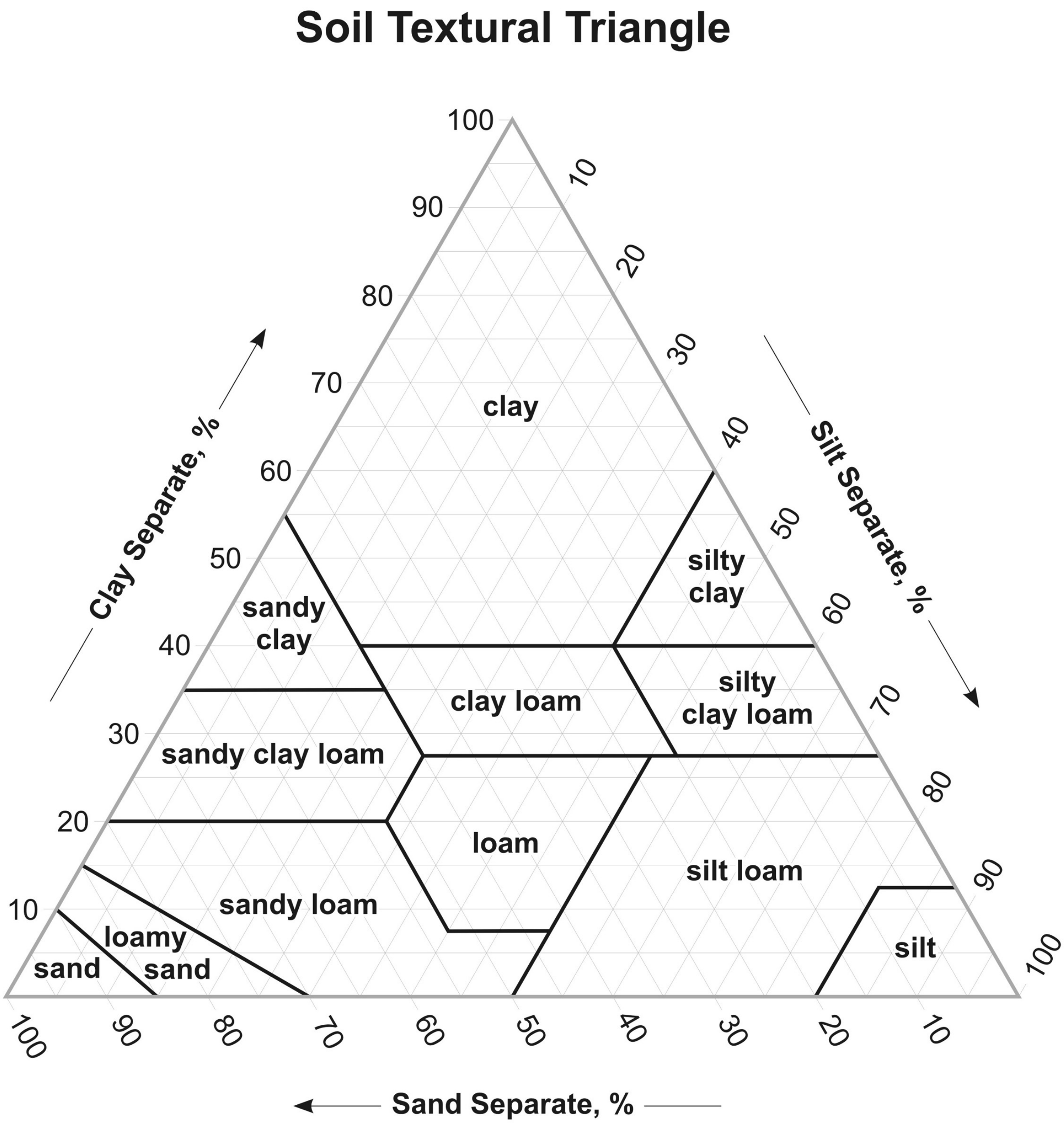

Image credit: USDA Natural Resources Conservation Service
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054311