NATIONAL GEOGRAPHIC

Activity*develop*

Soil Quality

How can we improve soil quality?

Overview

Students explore the conditions that make high-quality soils. Using data from field research and interactive computational models, they determine which farming practices best preserve and increase soil quality.

For the complete activity with media resources, visit:
http://education.nationalgeographic.org/activity/soil-quality/

Directions

1. Engage students in learning about soils and crop growth.

Tell students that plants grow better in high-quality soils than in lower-quality soils. Ask:

- *Soil quality is a measure of the level of nutrients in soil and its structure. How does plant growth reflect the soil quality?* (Plants grow better in high-quality soil because there are more nutrients in it. They grow less well in lower-quality soils because there are not sufficient nutrients.)
- *How do you think humans could improve the quality of soils?* (Answers will vary. Soil quality can be improved by adding more nutrients, which can be done by composting or leaving more roots in the soil year to year.)

2. Discuss the role of uncertainty in the scientific process.

Tell students that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. Let students know they can see examples of scientists' uncertainty in forecasting crop yields. Show the **Projection of Maize Crop Yields in France** graphs. (Download the image from the media carousel above by clicking on the down arrow in the lower right corner of the carousel window.) Tell students these graphs show the average daily precipitation, number of hot days, and yield of maize. The gray line shows the predictions for crop yield based on technological improvements. The pink shading shows the expected yield based on temperature and precipitation influences. The total uncertainty is shown by the red lines outside the pink shading. Ask:

- *Does the technology trend (gray line) accurately predict crop yields?* (No, the technology trend does not adequately predict crop yields. This is because crop yields are dependent on temperature and precipitation as well as technological improvements.)

- *Why do you think the crop models still have uncertainty even after accounting for precipitation and temperature differences year to year?* (Student answers will vary. The crop yield could be affected by a pest infestation.)

Tell students that they will be asked questions about the certainty of their predictions. Let students know that they should think about what scientific data is available as they assess their certainty with their answers. Encourage them to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce the concept of stocks and flows in a system.

Tell students that materials flow into and out of systems. The flow of the materials over time can change and can be influenced by many different factors and interacting parts.

Scientists think about how one part of the system can affect other parts of the system. Give students a simple example of a stock and flow in a system, as described in the scenario below.

There is a bathtub with water flowing in from the faucet and water leaving through the drain. Ask:

- *When the drain is plugged, what happens to the level of water in the bathtub?* (The water level will increase because the outflow of water is stopped, but water keeps coming in from the faucet.)

- *When the faucet is turned off, what happens to the level of water in the bathtub?* (The water level will decrease because the inflow of water is stopped, but the water keeps leaving through the drain.)

- *How can the level of water in the bathtub be kept at the same level?* (The water in the bathtub can be kept at the same level by making the inflow equal to the outflow. Then the water that comes in through the faucet will be offset by the water that leaves through the drain.)

Tell students they will be following the flow of materials, in this case the amount of topsoil and nutrients, through a system. Let students know they will be exploring some environmental and human factors that contribute to changes in the quality of soil in the modeled system.

4. Introduce and discuss the use of computational models.

Introduce the concept of computational models and give students an example of a computational model they may have seen, such as forecasting the weather. Project the **NOAA Weather Forecast Model**, which provides a good example of a computational model. Tell students that scientists use weather models to predict future conditions based on current information about the energy and moisture in the atmosphere. There are many different types of models. Scientists can use soil models to predict the movement and quality of soil in a region. Let students know that they will be using models of soil movement and quality.

5. Have students launch the Soil Quality interactive.

Provide students with the link to the Soil Quality interactive. Divide students into groups of two or three, with two being the ideal grouping to allow groups to share a computer workstation. Tell students they will be working through a series of pages of questions related to the data in the interactive. Ask students to work through the interactive in their groups, discussing and responding to questions as they go.

Tell students that this is Activity 4 of the **Can We Feed the Growing Population?** lesson.

6. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *In **Model 5: Landscape With Soil Quality Measurements**, how could you treat the soil to improve its quality?* (You can minimally till the soil, leaving roots in the soil year to year. This increases the soil quality.)
- *How does constantly tilling the soil decrease its quality?* (Lots of tillage breaks up the plant roots. This allows the soil to erode. When the soil erodes, it loses nutrients. That decreases the quality of the soil.)

Why does crop rotation work? (Different plants have different nutrient requirements. If you plant the same type of plant in a field year after year, the nutrients that it requires will be depleted from the soil. If you rotate other crops in, you have diversity in their nutrient requirements. Some plants add nutrients to the soil as they grow; legumes add nitrogen to the soil, for example. Using different crops to fertilize each other leads to less need for inorganic fertilizers.)

Tip

If you would like to save student data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

This activity is part of a sequence of activities in the Can We Feed the Growing Population? lesson. The activities work best if used in sequence.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking them the following questions:

- Why do plants grow better in high-quality soils than in low-quality soils?
- What type of tillage (intensive or conservative) results in better-quality soils? Why?
- How can plants increase soil quality?
- Why does crop rotation increase soil quality?
- What happens to plant growth if there are not enough nutrients in the soil?
- What are the consequences of adding too much fertilizer to plants?

2. Use the answer key to check students' answers on embedded assessments.

Objectives

Subjects & Disciplines

Science

- Earth science
- General science

Learning Objectives

Students will:

- describe the role of nutrients in plant growth
- describe how crop rotation can minimize the amount of fertilizer that needs to be added to the field
- describe a farming practice that can increase soil quality and decrease erosion

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning

- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes
  - Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

National Science Education Standards

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard F-1:**
Personal health
• **(5-8) Standard F-4:**
Risks and benefits
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard C-5:**
Matter, energy, and organization in living systems
• **(9-12) Standard F-1:**
Personal and community health
• **(9-12) Standard F-2:**
Population growth
• **(9-12) Standard F-4:**
Environmental quality
• **(9-12) Standard F-5:**
Natural and human-induced hazards

Common Core State Standards for English Language Arts & Literacy

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.11-12.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.6-8.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.9-10.4

ISTE Standards for Students (ISTE Standards*S)

- **Standard 3:**
Research and Information Fluency
- **Standard 4:**
Critical Thinking, Problem Solving, and Decision Making

Next Generation Science Standards

- **Crosscutting Concept 1:**
Patterns
- **Crosscutting Concept 2:**
Cause and effect: Mechanism and prediction
- **Crosscutting Concept 3:**
Scale, proportion, and quantity
- **Crosscutting Concept 4:**
Systems and system models
- **Crosscutting Concept 5:**
Energy and matter: Flows, cycles, and conservation
- **Crosscutting Concept 7:**
Stability and change
- **Science and Engineering Practice 1:**
Asking questions and defining problems
- **Science and Engineering Practice 2:**

Developing and using models
• **Science and Engineering Practice 3:**
Planning and carrying out investigations
• **Science and Engineering Practice 4:**
Analyzing and interpreting data
• **Science and Engineering Practice 5:**
Using mathematics and computational thinking
• **Science and Engineering Practice 6:**
Constructing explanations and designing solutions
• **Science and Engineering Practice 7:**
Engaging in argument from evidence
• **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information

Preparation

What You'll Need

Required Technology

- Internet Access: Required
- Tech Setup: 1 computer per learner, 1 computer per pair, 1 computer per small group, Interactive whiteboard, Projector

Physical Space

- Classroom
- Computer lab
- Media Center/Library

Grouping

- Heterogeneous grouping
- Homogeneous grouping
- Large-group instruction
- Small-group instruction

Resources Provided: Websites

- NOAA Weather Forecast Model

Resources Provided: Handouts & Worksheets

- Answer Key - Soil Quality

Resources Provided: Interactives

- Soil Quality interactive

Resources Provided: Images

- Projection of Maize Crop Yields in France

Background & Vocabulary

Background Information

Plant growth is affected by the amount of nutrients and moisture in the soil. High-quality soils contain a lot of organic matter, nutrients, and water. Soil quality is affected by farming practices.

Plowing and tilling can disrupt soil structure as the soil is turned over for planting. Two methods of tilling are compared in this activity: intensive tillage and conservative tillage. In intensive tillage, the soil structure is disturbed as it is completely turned over and thoroughly mixed. In conservative tillage, the soil is minimally disturbed during planting, cultivating, and harvesting. Conservative tillage leaves more plant roots in the soil, leading to more organic material in the soil and less erosion because the soil is better held together against the actions of wind and water.

Soil quality can be increased by returning organic matter to the soil. Composting is one way to return organic material to the soil. On a large scale, farmers can leave plant material in the field after harvest so that it can decompose and return nutrients to the soil, as is done in conservative tillage strategies.

The nutrients in soil can come from the decomposition of organic material, or inorganic fertilizers can be added to provide the nutrients that plants need. The nutrients commonly provided by fertilizer are nitrogen (N), phosphorus (P), and potassium (K). Nitrogen promotes the growth of leaves and vegetation. Phosphorus promotes root and shoot (stem) growth. Potassium regulates the water and nutrient movement in plant cells, promoting flowering and fruiting in plants.

There are consequences to adding too much fertilizer to plants. Adding fertilizers at the wrong time (such as when the plant is not growing) can lead to “fertilizer burn” as the plants lose water; fertilizers are salts. Adding too much fertilizer can result in runoff into nearby waterways in a heavy rain event. The nutrient-rich water can cause algal blooms in relatively nutrient-poor waterways far from the fertilizer application. (This is because algal growth in the waterways is generally nutrient-limited; the fertilizer adds the nutrient that was limited, leading to massive growth spurts.) As the algae die off and decompose, the oxygen content of the water drops, leading to large fish kills because the fish are no longer able to get enough oxygen to survive.

Different plants need different amounts of nutrients. Some types of plants, called legumes (which include peas, beans, soybeans, peanuts, alfalfa, and clover), have nodules on their roots. Nitrogen-fixing bacteria live in these nodules, producing nitrogen fertilizer as the plants grow. Thus, the legumes fertilize the soil with nitrogen as they grow. There is no need to add nitrogen to these crops because they produce their own.

Even though other types of plants do not produce nutrients as they grow, they still have different nutrient requirements. Alternating the types of plants that are planted in a field each year (crop rotation) allows a previous season's plants to provide nutrients for the next season's plants.

Prior Knowledge

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Recommended Prior Activities

- Climate and Crop Growth
- Preserving Soils
- Using the Land

Vocabulary

Term	Part of Speech	Definition
crop rotation	*noun*	the system of changing the type of crop in a field over time, mainly to preserve the productivity of the soil.
fertilizer	*noun*	nutrient-rich chemical substance (natural or manmade) applied to soil to encourage plant growth.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
system	*noun*	collection of items or organisms that are linked and related, functioning as a whole.

For Further Exploration

Reference

- National Geographic Encyclopedic Entry: rural area
- National Geographic Encyclopedic Entry: urban area
- National Geographic Encyclopedic Entry: agriculture
- National Geographic Encyclopedic Entry: fertility
- National Geographic Encyclopedic Entry: humus

Funder

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Partner