Kansas Apple Earth - Soil Diversity

Suggested Grade Level: 6th - 8th grades

Time: 60 minutes

Subject: Life Science, Earth and Space Science, Language Arts

Overview: Students use an apple to represent the Earth and discover how our land resources are used. Through critical thinking, students discover why topsoil is a nonrenewable resource, the importance of soil to our food supply, and the factors that impact topsoil distribution in different regions.

Objectives:

1. List the parts of the Earth's surface
2. Explain land use
3. Describe the ecosystem in soil
4. Explain the impact of human activities on ecosystems

Background Information :

Earth, the blue planet as observed from space, is almost three-quarters (¾ - 75%) water and one-quarter (¼ - 25%) land. The land area includes mountains, deserts, snow- and ice-covered polar regions, wetlands, forests, grasslands, and farmlands. These water and land areas are essential to the plants, animals, and microorganisms making up the global ecosystems. Not all land is created equal. Polar regions, deserts, salt flats, and exposed rock comprise one-third of the global land area. These areas are considered inhospitable and unsuitable for people to live or produce food. Two-thirds of our land is habitable. This land is located in climates where people can live and where they produce food. Half of the world's habitable land is covered in houses, cities, roads, and other developments. The remaining half of all habitable land is used for agriculture (Ritchie & Roser). So, only a tiny fraction of the total land area has the quality of topsoil, topography, available water, and length of growing season to permit cultivation.

Cultivated land areas provide the bulk of the world's food and fiber for humans. Whether the land is producing food crops, grazing livestock, or producing crops for livestock feed, it must have fertile topsoil. Agriculture depends on good soil. Fertile topsoil produces the highest yields of food per acre. While the world population is growing, the size of our Earth and the natural resources that provide for our needs are not. Farmers work hard to protect their soil. However, erosion, contamination, and other forms of soil loss can be complicated and expensive to address.

To further examine agricultural land use, 25% of agricultural land is used to produce food crops for direct human consumption. This land use includes the production of fruits, vegetables, beans, rice, grains, etc. The remaining 75% of agricultural land is used to feed livestock such as cattle, pigs, poultry, sheep, and goats. Livestock are raised throughout the world for meat, milk, and eggs. Livestock land use includes range and pasturelands used for grazing and croplands used to grow grain commodities fed to livestock (rather than people). Grain-based feeds are fed to beef cattle in the feedlot, dairy cattle during milk production, and poultry and pigs that convert their feed into other protein-based foods for humans.

Soil comprises both *living (biotic)* and *nonliving (abiotic)* elements. Soil contains air, water, minerals, and plant and animal matter. The disintegrating of rock forms soil under the influence of climate. Events such as temperature fluctuations (freezing and thawing) contribute to rock weathering into the substance we recognize as soil. Organic matter such as leaves, dead plant material, and decaying organisms contribute to the biotic components of soil.

"It is estimated that more than half of all earth species live in the soil! From the familiar earthworms to the lesser-known tardigrade and many undiscovered species. One gram of soil (a quarter of a tablespoon) can harbor up to 10 billion organisms - that's more than the number of people living on the planet! 95% of food production relies on the soil – healthy topsoil is vital to our existence on this planet, but we are losing topsoil at an alarming rate - between 10 and 40 times faster than it's formed. Soils store more carbon than the atmosphere, and all of the world's plants and forests combined, which means that soil is one of our most important weapons in the fight against climate change" (10).

"Soils that support natural, non-agricultural ecosystems usually have the greatest soil biodiversity. In agriculture, soils that receive less manufactured inputs (e.g., chemical fertilizers and pesticides) generally have higher soil biodiversity. Grazing systems that encourage plant diversity usually have higher soil biodiversity due to the greater availability of food resources from roots and litter, which support a greater variety of organisms in the soil. Cropping systems generally have low soil biodiversity unless they increase carbon and nitrogen inputs to the soil, which will increase soil microbial populations. Crop management techniques, developed through sustainable agriculture studies, that increase soil organic matter will also increase soil stability and soil biodiversity. Applying organic matter to the soil, such as crop stubble, supports greater populations of surface-feeding creatures, including earthworms and microbial decomposition. Management techniques such as crop rotation and reduced tillage increase the quantity and quality of organic matter available to soil organisms and develop a more stable environment that encourages more soil biodiversity" (Soil).

Agriculture is an integral part of the economy of the United States. In 2020, 19.7 million full- and part-time jobs were related to the agricultural and food sectors—10.3 percent of the total U.S. employment (USDA). Agricultural exports translated into billions of dollars

for United States trade. On poor soil, it costs farmers more to produce good crops; the higher cost is passed on to the consumer—you—in higher prices at the grocery store. Erosion reduces agricultural productivity and washes sediment into rivers, lakes, ocean gulfs, and bays, affecting fisheries and recreation opportunities in these water bodies. Soil loss affects our country's economy and our lives.

Kansas Connections:

Kansas Land

"The state is known for its vast plains, but it isn't all flatlands. Gentle hills with pastures and forests can be found in the northeast. This area is called the Dissected Till Plains. The land here was cut (or dissected) into hills and valleys by moving glaciers and wind over 400,000 years ago." The Southern Plains include the "Osage Plains, which are composed of eroded shale and limestone, and the Flint Hills, whose flint ridges stick up because flint doesn't erode (or break down) like other rocks and soil do. Kansas' western half is covered by the Great Plains, which rise in elevation as you continue west toward the Rocky Mountains. Near the Colorado border is Mount Sunflower, the state's highest point" (Kiffel-Alcheh).

"Kansas is the 15th largest state in the U.S., measuring 82,278 square miles, 213,099 square kilometers" (Amend). "The total Kansas land area in 2016 was 52,659,200 acres" (Farmland). "There are 45,759,319 acres of farmland in Kansas, which accounts for 87.5 percent of all Kansas land" (Kansas).

Kansas Economy

"Agriculture is the largest economic driver in Kansas, with a total contribution of $81 billion to the Kansas economy. The agriculture sector in Kansas supports more than 253,000 jobs through direct, indirect, and induced effect careers or about 13% percent of the entire workforce in the state" (Kansas).

Kansas Agriculture Production

The top five agricultural products grown or raised in Kansas include:

- Cattle and Calves
- Wheat
- Corn
- Sorghum
- Soybeans

Kansas is a recognized leader in agriculture in the United States.

- Kansas is ranked first in grain sorghum production, growing almost 64% of the nation's crop.
- Kansas is ranked second in sorghum for silage production.
- Kansas leads the nation in winter wheat production, growing 24% of the nation's crop.

- Kansas is ranked third in cattle production and beef processing.
- Kansas is ranked fourth in sunflower production.

Kansas is quickly becoming the new dairy frontier in the United States.

- Kansas is the 16th-ranked dairy state for milk production and is home to 173,000 dairy cows on over 210 dairy farms.
- Milk processing capacity has grown significantly in recent years, with the addition of processing facilities in Rexford, Garden City, and Hugoton.

Kansas Specialty Crop - Apples

- Kansas is not a leading producer of apples. The state does not produce enough to be recognized individually for apple production; however, apples are one of the most reliable fruit trees that can be grown in Kansas, and production is increasing (USDA).
- There are several (at least 7) apple orchards in the state, including 86th St. Orchard in Topeka; Cider Hill Family Orchard in Kansas City; Pome On the Range Orchards & Winery in Williamsburg; Sunflower Orchards in Paola; The Orchard in Emporia, KS; Wagon Wheel Orchard in Gardner, KS; and South Baldwin Farms in Douglas County. According to Kansas State University, the Delicious Golden, Granny Smith, Jonagold, Delicious, Jonathan, Empire, and Gala are the apple varieties that grow well in Kansas. Some of these orchards are called “U pick orchards” and allow people to come to pick fresh fruit directly from the trees.

Materials:

Demonstration

- Apple Land Use Model provided in Lesson Kit

Additional Materials for Live Apple Demonstration

- One Large Apple for each pair or group
- Pairing knife to cut the apple for each pair or group
- Plate for a surface to cut the apple for each group
- Paper towels or wet wipes - enough for each group

Activity

- “Topsoil in Our Food System” worksheet at the end of this lesson for each student

Instructional Format:

1. Review background information.
2. Conduct engagement exercises.
3. Follow the procedures to conduct the demonstration for students.
4. Lead a class discussion.
5. Complete the activity.
6. Conduct assessment exercise

Engagement:

Project this image:
https://cdn.agclassroom.org/media/uploads/LP551/nonrenewable_topsoil.png
Discussion:
What is featured in these pictures? (left to right, coal, oil pump for fossil fuels, stove burner using natural gas, and topsoil)
Does one picture stand out like it doesn't belong? why?
Which of these are renewable vs. renewable resources? (All are considered nonrenewable because they are in limited supply and can not be readily replaced at a pace quick enough to keep up with consumption).

Watch this YouTube video
Keep soil alive, protect soil biodiversity
https://www.youtube.com/watch?v=hbdsHOnd_gw

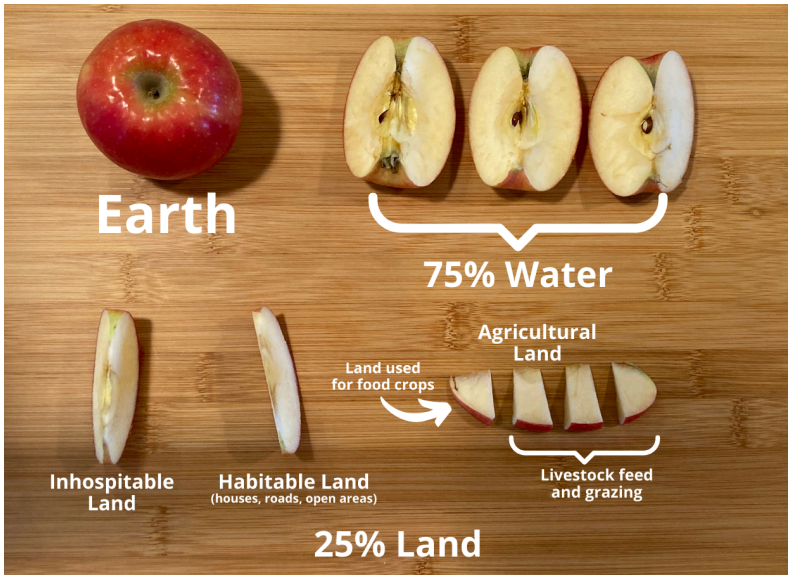
Ask students the following questions:

1. Why is soil considered a nonrenewable resource? *(It takes 2,000 years to form 10 centimeters of soil.)*
2. How is soil formed? *(the weathering of rocks over thousands of years)*
3. How do we lose soil? *(erosion and urbanization)*

Introduce the demonstration activity by letting students know that they will learn about the earth's surface and the importance of soil as a natural resource to grow our food.

Procedures:

Demonstration
Instructional Video on YouTube
Comparing Apples and……



1. Divide students into pairs or groups. Give each group an apple, a knife to cut the apple, a plate for a surface to cut the apple, and paper towels or wet wipes for clean up. (Cutting the apple can be for demonstration only by the teacher).

2. Hold up the Apple Land Use Model. “This Apple Model represents the planet Earth.” Hold up an apple to the class. This apple can also represent the earth.
3. Remove and hold up piece #1 of the Apple Model, that is ¾ of the top layer of the model. “Nearly three-quarters of the Earth is covered in water.” Ask one person in each group to slice the apple into fourths or four equal-sized pieces. Ask them to think about and discuss making four equal pieces before cutting. Ask each group to set aside three-quarters representing water on the Earth’s surface.
4. Ask students, “What does the remaining ¼ of the apple represent?” “The remaining quarter represents the area of the earth that is land.” Ask students to compare the piece of the apple that represents land and the three pieces that represent water. How much more water than land is there on the earth? (3 times more water than land).
5. Remove and hold up piece #2 of the Apple Model. “This section represents inhospitable land including deserts, mountains, and polar regions that are unsuitable for people to live or grow crops.” Ask another student in the group to cut the quarter of the apple representing land into three sections. Have the student set aside one of the sections to represent the inhospitable land. What is inhospitable land?
6. Remove and hold up piece #3 of the Apple Model. "This section represents habitable land. People live on this land, but crops are not grown here as this land includes nature preserves, public lands, and developed areas like roads, schools, houses, etc. Explain to students that the two pieces of apple represent habitable land. Ask another student in the group to set aside another section to represent habitable land where people live, but crops are not grown.
7. Remove and hold up piece #4. “A tiny portion of the Earth’s surface has the potential to grow crops. This section of the model and the last piece of the apple represent arable land.” Ask another student to cut the remaining small piece of apple into four pieces. Explain that three pieces represent land used for livestock to graze or produce forages for livestock feed. Ask a student to set aside the three pieces representing the agricultural land used for livestock.
8. The remaining piece of apple is the 1/48th of the Earth used to produce human food. Ask another student to cut the peel from the peel from the remaining piece of apple and explain to students that the small piece of apple peel represents the topsoil used to grow all human food.
9. Ask students to compare the amount of the apple they set aside to the amount used for agriculture and the size of the peel that represents topsoil.

Class Discussion

1. Why can't we grow food on all of the land on Earth? (Climate. Average temperatures, seasons, and rainfall determine what crops (if any) can be grown in a given place. Some land is inhospitable.)
2. How does urbanization impact agricultural land use? (Urbanization takes place in habitable land. It decreases the amount of land available for agriculture while simultaneously creating more demand for food and other agricultural products as populations grow.)
3. Can you think of any food that is not accounted for in this activity? (Most of our food comes from agricultural land, but food like fish and shellfish come from water like oceans, rivers, and lakes. Some of our food can also be grown in home gardens and greenhouses.)
4. What can we learn from this demonstration? (Answers will vary. Direct discussion to conclude that the amount of habitable land where we can live and produce our food is extremely limited. We need to use it wisely and protect it.)

Activity

1. Post or project the vocabulary words.
2. Have students complete the "Topsoil in Our Food System" worksheets.

Vocabulary:

- **soil biodiversity**: the variety of life that exists within the soil, including bacteria, fungi, earthworms, and termites
- **soil microorganisms:** a group of microscopic life forms that include bacteria, archaea, viruses, and eukaryotes like fungi.
- **soil contaminant:** any substance in the soil that exceeds naturally-occurring levels and poses human health risks eg. arsenic naturally occurs in some soils, but if a person sprays a certain pesticide on a yard, that could cause contamination.
- **carbon:** an element that takes the solid form of either graphite or diamond. Carbon is one of the basic elements of any living thing. Carbon is known as the most essential element for life, and it's the second most abundant — after oxygen — in the human body
- **microbial decomposition:** Bacteria break down (or decompose) dead organisms, animal waste, and plant litter to obtain nutrients.
- **Climate change:** long-term shifts in temperatures and weather patterns
- **Ecosystem**: a biological community of interacting organisms and their physical environment
- **conservation tillage**: farming methods that reduce the intensity or frequency of tilling in order to maintain some ground cover throughout the year and disturb the soil as little as possible while still providing the conditions needed to grow a productive crop

- **nonrenewable resource**: limited natural resource that cannot be replaced or reproduced within a generation and cannot be managed for renewal; examples include oil, soil, and mineral resources (lead, iron, cobalt, zinc, etc.)
- **sustainable agriculture:** an approach to agriculture that focuses on producing food while improving the economic viability of farms, protecting natural resources, and enhancing quality of life for farmers and society as a whole

Assessment:

1. Have students write a story about the effects of changes in the soil quality on biodiversity and the soil ecosystem using vocabulary words. Explain the impact of changes in the soil ecosystem on other ecosystems. (This assessment could be extended to a research project that would meet many additional Kansas academic standards, including constructing arguments and using research.)
2. Have students share and discuss their stories with a partner. Have partners check facts and offer suggestions for revisions and editing

Kansas Curricular Standards:

Next Generation Science Standards

Middle School

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

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

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

Science and Engineering Practices

Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Analyze and interpret data to determine similarities and differences in findings.

Disciplonary Core Ideas

ESS3.C: Human Impacts on Earth Systems Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MSESS3-3),(MS-ESS3-4)

Crosscutting Concepts Patterns

Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2) *Cause and Effect* Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3) Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-4)

(MSESS3-2)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. Apply scientific principles to design an object, tool, process or system. (MS-ESS3-3)

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Language Arts

6th grade

SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.
SL.6.2 Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.
SL.6.8 Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.
RI.6.2 Determine a central idea of a text and how it is conveyed through particular details; provide a summary of the text distinct from personal opinions or judgments.
RI.6.7 Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.
RI.6.8 Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not.
RI.6.10 Use knowledge of language and its conventions when reading to improve comprehension.

7th grade

W.7.1 Write arguments to support claims with clear reasons and relevant evidence
W.7.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
W.7.3 Write narratives to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences.
W.7.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. W.7.5 With some guidance and support from adults and peers, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.
W.7.10 Demonstrate command of the conventions of standard English grammar and usage when writing.
W.7.11 Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
SL.7.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacherled) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.
SL.7.2 Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study.

8th grade

W.8.1 Write arguments to support claims with clear reasons and relevant evidence.
W.8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
W.8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. W.8.5 With some guidance and support from adults and peers, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.
W.8.10 Demonstrate command of the conventions of standard English grammar and usage when writing.
W.8.11 Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacherled) with diverse partners on Grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

SL.8.2 Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively, orally) and evaluate the motives (e.g., social, commercial, political) behind its presentation.
SL.8.7 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking
SL.8.8 Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.

National Ag Literacy Outcomes:
Agriculture and the Environment

- Discover how natural resources are used and conserved in agriculture (e.g., soil conservation, water conservation, water quality, and air quality) (T1.6-8.c)
- Describe the benefits and challenges of using conservation practices for natural resources (e.g., soil, water, and forests) in agricultural systems which impact water, air, and soil quality (T1.6-8.b)

Companion Resources: (supplemental documents)

KFAC Topsoil in Our Food System poster

"Apple Earth," YouTube https://www.youtube.com/watch?v=v9WXCAwk4_c
Earth: The Apple of our Eye
https://populationeducation.org/video-transcript/earth-the-apple-of-our-eye/
Journey 2050 Lesson 5: Land Use (grades 6-8) https://agclassroom.org/matrix/lesson/593/

Book: *Food and Agriculture*, Spilsbury

How America Uses its Land (a series of interactive maps illustrating how land is used in America) https://agclassroom.org/matrix/resource/1027/

Author: Adapted by Nancy Zenger-Beneda from the NAITCO lesson plan "Land and Soil in the Ecosystem." https://agclassroom.org/matrix/lesson/550/

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Name:_____

Topsoil in Our Food System

Review the poster and then answers to the questions

How is topsoil different than other layers of soil in the Earth's crust?

Why is topsoil important to our food supply?

What is soil composed of?

Why is soil considered a non-renewable resource?

Is topsoil a resource that is distributed equally throughout the world? Why or Why not?

Name:_____

Topsoil in Our Food System

Vocabulary

Soil Biodiversity =

Soil Microorganisms =

Soil Contaminant =

Carbon =

Microbial Decomposition =

Climate Change =

Ecosystem =

Conservation Tillage =

Nonrenewable Resource =

Sustainable Agriculture =

Topsoil in Our Food System

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