Course	Agricultural Science II
Unit	Soil Science
Lesson	Importance of Soil
Estimated Time	Two 50-minute blocks

Student Outcome

Explain the importance of soil.

Learning Objectives

1. Explain what soil is.
2. Identify reasons for studying soil.
3. Explain how soils are different.
4. Identify career opportunities in soil science.

Grade Level Expectations

SC/ES/3/A/09-11/a SC/ES/3/A/09-11/e

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slide
   - PPt 1 – Soil Definition
2. Activity Sheet
   - AS 1 – Making Soil Artificially
3. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
4. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplies & Equipment

- ❑ Growing plant
- ❑ Various soil samples
- ❑ See AS 1 for materials and equipment needed to complete the Activity Sheet.

Supplemental Information

1. Internet Sites
   - ❑ The Cooperative Soil Survey. Missouri Cooperative Soil Survey. Accessed May 13, 2008, from http://www.soilsurvey.org/.
   - ❑ Missouri Soil Survey Program. USDA Natural Resources Conservation Service. Accessed May 13, 2008, from http://www.mo.nrcs.usda.gov/technical/soils/soilsur_index.html.
   - ❑ Missouri Soils Data. Missouri Spatial Data Information Service. Accessed May 13, 2008, from http://www.msdis.missouri.edu/data/soilsviewer/index.htm.
   - ❑ Soil Science Education Home Page. Goddard Space Flight Center, NASA. Accessed May 13, 2008, from http://soil.gsfc.nasa.gov/index.html.

- ❑ Soil-net.com. Cranfield University's National Soil Resources Institute, United Kingdom. Accessed May 13, 2008, from http://www.soil-net.com/.
- ❑ Soils Around the World. WGBH Educational Foundation. Accessed May 13, 2008, from http://www.teachersdomain.org/resources/ess05/sci/ess/earthsys/soils/.

2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.
   - ❑ Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
   - ❑ Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
   - ❑ Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
   - ❑ Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
   - ❑ White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

1. Ask students how soil is important to them. Have students bring small samples of soil from their yards and identify similarities and differences. Have students list what they think makes up their soil.
2. Use an actual growing plant to demonstrate the importance of soil and how it affects the growth of the plant. Have the students explain the interdependence of the plant and soil.
   a. What does the soil do for the plant?
   b. What does the plant do for the soil?

Communicate the Learning Objectives

1. Explain what soil is.
2. Identify reasons for studying soil.
3. Explain how soils are different.
4. Identify career opportunities in soil science.

Instructor Directions	Content Outline
Objective 1 *Discuss what soil is. Soil has different meanings for different people. Ask students to give their own definition of soil. Display PPt 1 to use as a guide. Have students complete AS 1 to show how forces of nature can create soil from parent material.* PPt 1 – Soil Definition AS 1 – Making Soil Artificially	**Explain what soil is.** 1. Soil has different meanings for different people. 2. To the farmer, soil is a medium in which crops grow. 3. To the engineer, soil is a building material which supports foundations, roads, or airport runways. 4. The public, in most cases, just takes the soil for granted. It is just "dirt." 5. To the soil scientist, soil is a living, naturally occurring dynamic system at the interface of air and rock. 6. Soil covers the earth in a very thin layer and supports plants and supplies them with air, water, and nutrients. 7. Soils form in response to forces of climate and organisms that act on parent material in a specific landscape over a period of time.
Objective 2 *Discuss the importance of soil and how it affects people. Discuss human dependence on the soil. Contrast plant life with human life. Humans cannot manufacture their own food from the four primary resources of soil, air,*	**Identify reasons for studying soil.** 1. Soil is an essential natural resource that needs to be used properly and protected. 2. A study of soil will increase understanding of how this resource supports life. 3. Soil is composed of layers or horizons that are described in terms of their properties. If soils are

Instructor Directions	Content Outline
water, and sunlight. Human life depends completely on green plants that take nutrients and water from soil and combine them with air and sunshine to provide a food supply.	managed properly, they will continue to support people for many generations to come. 4. People depend on soil: It is expected to produce crops, support buildings and highways, grow trees for forests, provide places for recreation and wildlife habitats, and be a safe place for disposal of wastes. 5. Missouri has nearly 1,000 different soil types. It is necessary to study the soil before beginning construction or planting a crop so that its hazards and limitations are known.
Objective 3 *Use actual soil samples and discuss the physical characteristics of each. (Caution – do not go into a lot of detail at this time. This lesson is an introduction and should provide an overview, rather than an in-depth analysis of soil properties.)*	**Explain how soils are different.** 1. Missouri alone has nearly 1,000 different soil types, ranging from deep to shallow, clayey to sandy, wet to dry, and level to very steep. 2. Some of the differences in soils are so slight (like small differences in the thickness, percent of organic matter of the surface layer, or the amount of clay in the subsoil) that it is hard to tell them apart except under close examination. 3. Some of the differences are significant, such as the difference between a shallow soil that is 10 inches deep compared to one that is over 72 inches deep, or a soil containing 25 percent clay compared to a soil containing 60 percent clay.
Objective 4 *Discuss the careers that are available in soil and crop management.*	**Identify career opportunities in soil science.** 1. Agricultural production a. Farm manager b. Land specialists for banks c. Technical representatives for fertilizer firms 2. Natural resources a. Soil scientist in public service agencies b. Technician for recreational industries 3. Environmental science a. Government agent b. Private consultant for waste management and water quality issues

Instructor Directions	Content Outline
Application AS 1 – Making Soil Artificially	Answers to AS 1: 1. The rocks break or crack as they contract after their expansion by heating. 2. The bubbles are carbon dioxide gas made from carbon and oxygen released from the limestone by a chemical change in the rock caused by the acid in the vinegar. 3. Freezing water expands with tremendous force. Water finds its way into the cracks in the rocks, freezes, and breaks the rock into smaller and smaller pieces. Other activities: 1. Invite a guest speaker from a soil science area. 2. Ask the students to list the ways in which soils affect the quality of their lives. 3. Take a field trip to observe different soils. 4. Bring in soil samples for examination.
Closure/Summary	All life depends on soil; therefore, it is important for people to study the soil so they can learn how to protect it for the future.
Evaluation: Quiz	Answers (answers may vary): 1. Soil is a living, naturally occurring dynamic system at the interface of air and rock. 2. Soil is an essential natural resource. A study of soil will increase an understanding of its proper use and protection, how soil supports life, what soil is made of, proper management of the soil, and how soils are different. 3. Some of the differences in soils are slight, like small differences in thickness, the percent of organic matter of the surface layer, or the amount of clay in the subsoil. Other differences are significant, such as the difference between a shallow soil that is 10 inches to bedrock compared to one that is over 72 inches to bedrock, or a soil containing 25 percent clay compared to a soil containing 60 percent clay.

Instructor Directions	Content Outline
	4. a. Farm managers Land specialists for banks Technical representatives Government jobs Private institutions b. Public service agency job Recreational industries c. Government agency jobs Private consulting jobs 5. Soil supports life. Knowing that, people must study the soil so that they can learn how to protect it for future use.

Course	Agricultural Science II
Unit	Soil Science
Lesson	Soil Formation
Estimated Time	Three 50-minute blocks

Student Outcome

Describe how soils are formed.

Learning Objectives

1. Describe how climate, organisms, parent materials, topography, and time affect soil formation.
2. Describe how the soil-forming processes affect soil development.
3. Describe how the soil-forming processes work together to form soil.
4. Explain why soils are different.

Grade Level Expectations

SC/ME/1/B/09-11/c SC/ES/1/B/09-11/a SC/ES/2/A/09-11/a

SC/ES/2/A/09-11/b

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - ☐ PPt 1 – How Climate Affects Development of Organic Matter
   - ☐ PPt 2 – Why Soils are Different
2. Activity Sheet
   - AS 1 – Life in the Soil
3. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
4. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplies & Equipment

- ❑ See AS 1 for materials and equipment needed to complete the Activity Sheet.

Supplemental Information

1. Internet Sites
   - ❑ Soil Formation and Classification. USDA Natural Resources Conservation Service. Accessed May 14, 2008, from http://soils.usda.gov/education/facts/formation.html.
   - ❑ Soil Geology. Seafriends Marine Conservation and Education Centre, New Zealand. Accessed May 14, 2008, from http://www.seafriends.org.nz/enviro/Soil/geosoil.htm.
2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.

- Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
- Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
- Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
- Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
- White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

After reviewing similarities and differences in their soils from home, have the students list what forces might have influenced the formation of their particular soil. Let the students know that although time is an important factor in soil formation, the "age" of a soil is usually measured in development, not in years.

Communicate the Learning Objectives

1. Describe how climate, organisms, parent materials, topography, and time affect soil formation.
2. Describe how the soil-forming processes affect soil development.
3. Describe how the soil-forming processes work together to form soil.
4. Explain why soils are different.

Instructor Directions	Content Outline
Objective 1 *Discuss how the five soil-forming factors influence soil formation. Discuss the difference between active and passive factors. Of the five soil-forming factors, climate and organisms are active factors. They are catalysts that cause soil to form. The other three factors (parent material, topography, and time) are passive factors. They respond to the forces exerted by climate and organisms. All five factors are closely interrelated and few generalizations can be made about the effect of any factor unless conditions are specified for the other four factors. Display PPt 1 when discussing climate. Have students complete AS 1 after discussing organisms.* PPt 1 – How Climate Affects Development of Organic Matter AS 1 – Life in the Soil	**Describe how climate, organisms, parent materials, topography, and time affect soil formation.** Climate 1. Temperature a. Rate of chemical activity b. Type of vegetation and biological activity 2. Rainfall a. Leaching b. Movement of clay particles Organisms (Refer to Figure 2.1 in Student Reference.) 1. Macroorganisms: living and dead a. Source of all organic matter b. Include large plants and animals c. Plants being the largest contributor of organic matter d. Large trees – Decay slowly – Break up soil and leave channels e. Soil animals – Contribute organic matter – Mix the soil and leave channels 2. Microorganisms (microbes) a. Microscopic plants and animals b. Primary decomposers of organic material c. Humus, produced by microbes, acts as glue for soil aggregates d. Without microbes, inert soil

Instructor Directions	Content Outline
	3. Finely divided nonliving material a. Humus – Amorphous (formless) – Dark brown or black Parent material 1. Original geologic material 2. Passive 3. Residuum: formed in place from bedrock 4. Transported: deposits of sediments a. Colluvium b. Alluvium c. Loes d. Glacial till Topography 1. Relief or landscape 2. Influences soil formation: drainage, runoff, erosion, sunlight, and wind Time 1. "Young" soils more closely resemble their parent materials. 2. Some parent materials weather faster than others. 3. Climates may change with the passage of time.
Objective 2 *Discuss the four major processes that change parent material into life-sustaining soil. These processes are a result of catalytic influences of the active factors (organisms and climate).*	**Describe how the soil-forming processes affect soil development.** 1. Additions a. Organic matter gives black or dark brown color to the surface layer. b. Rainfall adds nitrogen. c. Acid rain may change the rate soil processes. d. Flooding adds new sediment. 2. Losses a. Leaching – Free lime or salts – Fertilizers (especially nitrogen) b. Slowly dissolving minerals: residual effects of weathering

Instructor Directions	Content Outline
	c. Gases – Oxygen from organic decay – Water vapor from organic decay – Nitrogen changed to gas by wetness d. Solids (mineral and organic): solids lost by erosion are the most serious loss. 3. Translocations a. Movement of particles from the surface soil to subsoil b. Caused by water – This movement carries clay particles – Incomplete leaching leaves mineral deposits 4. Transformations a. Changes that take place within the soil – Microorganisms – Chemical weathering b. Changes of elements – Reduction of iron oxide – Mottling caused by repeated cycles of wetting and drying
Objective 3 *Obtain samples of common soil-forming rocks and minerals. Discuss what processes must happen to change these parent materials to soil. Discuss how the different layers in a soil profile might have been formed.*	**Describe how the soil-forming processes work together to form soil.** 1. Climate acts immediately. 2. Physical weathering decreases size of parent material. 3. Weathering changes minerals. 4. Leaching removes salts and limes. 5. Plants add organic matter. 6. Biological activity increases (humus is formed). 7. Increased porosity allows more leaching and weathering. 8. Chemical weathering and leaching continue to change and remove minerals. 9. More horizons develop beneath the surface. 10. The soil becomes more acid. 11. Clay minerals begin to form. 12. Clay is translocated and clay films become visible. 13. Rate of water movement through the soil decreases. 14. Weathering continues, but leaching is not as rapid. 15. Changes continue at a very slow rate.

Instructor Directions	Content Outline
Objective 4 *Observe differences in Missouri soil. Discuss why soils are different. Discuss what might have caused the differences. Display PPt 2 and discuss how these causes may have interacted.* ☐ PPt 2 – Why Soils are Different	**Explain why soils are different.** 1. Factors are closely interrelated in the effects on soil. The five factors interact with each other and the four major soil-forming processes. 2. Soil-forming processes are also closely interrelated in the effects on soil. The four major soil-forming processes interact with each other and the five factors.
Application AS 1 – Life in the Soil	Answers to AS 1: 1. To be determined by the student. 2. Yes 3. Earthworms feed on fresh organic matter, making the nutrients available to plants. Earthworms bring soil from lower levels to the surface, thus mixing the soil. Earthworms improve aeration and internal drainage of the soil. Other activities: 1. Take a field trip and study the history of local soils to see how different soils are formed. 2. Demonstrate the effects of heat in the soil-forming process. Explain what will be done and ask students for predictions. Heat a rock and drop it into ice water (in a non-glass container). Observe the results. Draw conclusions. USE EXTREME CAUTION. 3. Demonstrate the effects of cold in the soil-forming process. Explain what will be done and ask students for predictions. Put wet clay in a jar or plastic bag so it is full and is a tight fit. Freeze it and observe the results. Draw conclusions. 4. Demonstrate the effects of wetting and drying in the soil-forming process. Explain what will be done and ask students for predictions. Take a moist clod of clay. Cut it square. Put two pins in it and measure the distance between them. Put the clay (with the pins) in the oven to dry. Take it out of the oven and measure the distance between the pins. Compare the two measurements. Draw conclusions.

Instructor Directions	Content Outline
Closure/Summary	The active factors of soil formation (climate and organisms), together with the passive factors (parent material, topography, and time) are so closely interrelated in their effects on the soil that few generalizations can be made unless conditions are known for all of them. The soil-forming processes (additions, losses, translocations, and transformations) may add further variability.
Evaluation: Quiz	Answers: 1. b 2. e 3. c 4. d 5. f 6. a 7. i 8. h 9. g 10. j

Course	Agricultural Science II
Unit	Soil Science
Lesson	Soil Color
Estimated Time	50 minutes

Student Outcome

Explain the importance of soil color.

Learning Objectives

1. Explain the importance of soil color.
2. Describe how the matrix color of soil is identified.
3. Describe how organic matter affects soil color.
4. Identify other factors which affect soil color.
5. Explain soil mottling.
6. Describe what causes soil mottling to occur.
7. Describe how mottles are identified.
8. Explain what a Munsell color notation indicates.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
2. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplies & Equipment

- ❑ Munsell color chart

Supplemental Information

1. Internet Sites
   - ❑ The Color of Soil. USDA Natural Resources Conservation Service. Accessed May 15, 2008, from http://soils.usda.gov/education/resources/k_12/lessons/color/.
   - ❑ Fletcher, Peter C., and Peter L.M. Veteman. *Soil Morphology as an Indicator of Seasonal High Water Tables.* Accessed May 15, 2008, from http://nesoil.com/properties/eshwt.htm.
   - ❑ Horizon Properties: Soil Color – Munsell Notation. Goddard Space Flight Center, NASA. Accessed May 15, 2008, from http://soil.gsfc.nasa.gov/pvg/munsell.htm.
   - ❑ Munsell Soil Color Charts, available in sets or individual pages from Forestry Suppliers, Inc. The three Munsell color charts recommended most often are the 10YR, 7.5YR, and 5YR. Three additional charts are used periodically: 5Y, 2.5Y, and 2.5YR. Accessed May 15, 2008, from http://www.forestry-suppliers.com/product_pages/View_Catalog_Page.asp?mi=3078.

2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.
   - ❑ Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
   - ❑ Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
   - ❑ Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
   - ❑ Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
   - ❑ White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

Show the Munsell color chart. Examine again the samples from home. Have the students predict what the different colors in their samples might mean.

Communicate the Learning Objectives

1. Explain the importance of soil color.
2. Describe how the matrix color of soil is identified.
3. Describe how organic matter affects soil color.
4. Identify other factors which affect soil color.
5. Explain soil mottling.
6. Describe what causes soil mottling to occur.
7. Describe how mottles are identified.
8. Explain what a Munsell color notation indicates.

Instructor Directions	Content Outline
Objective 1 *Discuss the importance of soil color. Ask the students if color affects soil or is an indicator of soil condition and composition.*	**Explain the importance of soil color.** 1. Color is one of the most noticeable properties. 2. Color gives clues about the nature of the root zone. a. Organic matter content b. Wetness c. Air-water relations
Objective 2 *Discuss how the matrix color of soil is identified. Refer to the color plates in the student reference. Remind students that soil color is identified using moist (not wet) soil and is studied in the brightest light available. Use freshly exposed samples.*	**Describe how the matrix color of soil is identified.** 1. Main body of soil 2. Dominant color of the horizon a. Moist soil b. Brightest lighting 3. Grouped in four broad classes a. Dark brown, very dark brown, black b. Light brown, brown, yellowish brown c. Red, reddish brown d. Dark gray, light gray, white
Objective 3 *Discuss the importance of organic matter. Is color an indicator we use to determine the amount of organic matter in the soil?*	**Describe how organic matter affects soil color.** 1. Humus (organic residue) coats soil particles 2. Causes dark color 3. Dark color increases as humus increases 4. Typical of A horizons 5. Breaks down slower in wet soils

Instructor Directions	Content Outline

Objective 4
 	
Discuss what other factors might affect the color of soil. Ask students what they believe causes the dominant soil color in your area.
	Identify other factors which affect soil color.
	
	1. Wetness
	2. Aeration: iron oxide coatings
	3. Weathering
	  a. Leached
	  b. Acidic
	4. Mineral color: naturally gray

Objective 5
 	
Discuss what soil mottling is. Discuss the color plates in the student manual.
	Explain soil mottling.
	
	1. Splotches of soil colored differently than the dominant matrix color
	2. Examples:
	  a. Reddish brown splotches in a gray matrix
	  b. Gray splotches in a brown matrix

Objective 6
 	
Discuss what causes soil mottling.
	Describe what causes soil mottling to occur.
	
	1. Seasonal high water tables in landscapes that restrict water movement (drainage mottles)
	  a. High water table
	  – Blocks air circulation
	  – Removes iron oxide coatings (gray mottle)
	  b. Low water table
	  – Allows air circulation
	  – Develops iron oxide coatings (yellowish-brown mottle)
	2. Chemical weathering
	  a. Minerals change color
	  b. Rocks fragment
	3. Coatings on soil aggregates
	  a. Not considered a soil mottle
	  b. Usually dark in color
	  – Organic coatings
	  – Clay coatings
	  – Moisture films

Objective 7
 	
Discuss how mottles are identified. Discuss the four properties of mottle patterns. Use Figure 3.1 in the student reference as a guide.
	Describe how mottles are identified.
	
	1. Abundance
	  a. Few: less than 2% of exposed surface
	  b. Common: 2 to 20% of exposed surface
	  c. Many: more than 20% of exposed surface

Instructor Directions	Content Outline
	2. Size a. Fine: diameter less than 5 mm b. Medium: diameter 5 to 15 mm c. Coarse: diameter more than 15 mm 3. Contrast a. Faint: evident only on close examination b. Distinct: readily seen though not striking c. Prominent: conspicuous 4. Color a. Dark brown, very dark brown, black b. Light brown, brown, yellowish brown (common mottle color) c. Red, reddish brown (common mottle color) d. Dark gray, light gray, white (common mottle color)
Objective 8 *Show the students a Munsell color chart in the classroom. The Munsell Color Company makes small color chips for each combination of variables. Use the example 10YR 4/6 listed in the student reference to discuss what this Munsell color notation indicates for this particular soil.*	**Explain what a Munsell color notation indicates.** 1. Hue (color) indicated by first number and letter—initials of color name 2. Value (light to dark) indicated by fraction numerator: scale of 0 (black) to 10 (white) 3. Chroma (brightness or purity) indicated by denominator: scale of 1 (dull) to 8 (bright)
Application	Other activities: 1. Using the Munsell color chips, examine your local soil for all of the color factors in this lesson.
Closure/Summary	Soil color is one of the most noticeable of soil properties. Soil matrix color also gives clues about the nature of the root zone. Soil mottling gives clues as to seasonal high water tables. To be consistent, samples should always be evaluated using moist soil in the brightest available light.
Evaluation: Quiz	Answers: 1. a 2. b 3. d 4. g 5. c 6. e 7. h

Instructor Directions	Content Outline
	8. f 9. Dark brown, very dark brown, black 10. Light brown, brown, yellowish brown 11. Red, reddish brown 12. Dark gray, light gray, white

Course	Agricultural Science II
Unit	Soil Science
Lesson	Soil Texture
Estimated Time	Two 50-minute blocks

Student Outcome

Explain the importance of soil texture.

Learning Objectives

1. Explain the term soil texture.
2. Identify the three major separates in fine earth.
3. Explain what the different soil textures are and how they are determined.
4. Explain what rock fragments are and how they are identified.
5. Explain the term pore space.
6. Describe the importance of pore space.
7. Explain the relationship between soil texture and pore space.
8. Describe how other factors are affected by soil texture.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - ☐ PPt 1 – Flowchart for Estimating Textural Class
   - ☐ PPt 2 – Relative Sizes of Sand, Silt, and Clay
   - ☐ PPt 3 – Textural Triangle
   - ☐ PPt 4 – The Soil Triangle
2. Activity Sheet
   - AS 1 – Are All Soil Particles the Same Size?
3. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
4. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplies & Equipment

- ❑ See AS 1 for materials and equipment needed to complete the Activity Sheet.

Supplemental Information

1. Internet Sites
   - ❑ Horizon Properties: Soil Texture. Goddard Space Flight Center, NASA. Accessed May 15, 2008, from http://soil.gsfc.nasa.gov/pvg/texture1.htm.
   - ❑ Soil Texture. Institute of Food and Agricultural Sciences Extension, University of Florida. Accessed May 15, 2008, from http://edis.ifas.ufl.edu/SS169.
   - ❑ Soil Texture (animation showing what kind of soils are created from different silt, sand, and clay content levels). Soil Science Department, North Carolina State University. Accessed May 15, 2008, from http://courses.soil.ncsu.edu/resources/physics/texture/soiltexture.swf.
   - ❑ Soil Texture Calculator. USDA Natural Resources Conservation Service. Accessed May 15, 2008, from http://soils.usda.gov/technical/aids/investigations/texture/.
2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.
   - ❑ Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
   - ❑ Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
   - ❑ Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
   - ❑ Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
   - ❑ White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

Illustrate how texture influences the workability of soil. Compare working clay and sandy soil.

Communicate the Learning Objectives

1. Explain the term soil texture.
2. Identify the three major separates in fine earth.
3. Explain what the different soil textures are and how they are determined.
4. Explain what rock fragments are and how they are identified.
5. Explain the term pore space.
6. Describe the importance of pore space.
7. Explain the relationship between soil texture and pore space.
8. Describe how other factors are affected by soil texture.

Instructor Directions	Content Outline
Objective 1 *Have students assist you in doing a demonstration on soil texture. Perform the ribbon or feel test to determine how easily the soil can be molded. Refer to PPt 1.* ☐ PPt 1 – Flowchart for Estimating Textural Class	**Explain the term soil texture.** 1. Refers to the percentage by weight of sand, silt, and clay in a soil. 2. A balanced mixture is called loam. 3. Texture affects soil behavior. 4. Texture classifications also refer to the presence of gravel or cobblestones.
Objective 2 *Show PPt 2 to the students. Have the students demonstrate the surface area of soil particles by pouring water over a pile of marbles. Most of the water runs quickly away. Droplets clinging to the surface of the marbles are the only water retained in the pile, since water cannot soak into the marbles. Using the rule about particle size, a pile of small beads holds more water than a pile of marbles because it has more surface area. Complete AS 1 with the students.*	**Identify the three major separates in fine earth.** 1. Sand: particles are large and can be seen with the naked eye. a. Range in size from 0.05 mm to 2 mm b. Feels gritty c. Will not stick together when wet d. Low capacity for holding moisture and storing nutrients 2. Silt: particles are smaller than sand and cannot be seen without a hand lens or microscope. a. Range in size from 0.002 mm to 0.05 mm b. Feels smooth (like flour or corn starch) c. Not sticky d. Holds large amounts of water in a form plants can use

Instructor Directions	Content Outline
☐ PPt 2 – Relative Sizes of Sand, Silt, and Clay 🖹 AS 1 – Are All Soil Particles the Same Size?	3. Clay: particles are very small and flat and can be seen only with high-powered microscopes. a. Less than 0.002 mm in size b. High water holding capacity c. Feels sticky; can be molded into ribbons or wires
Objective 3 *Discuss the fact that all soil contains a mixture of the three major separates of sand, silt, and clay. Show the students PPt 3. Explain that loam is a balanced mixture of the three separates. Discuss how soil texture can be thought of in terms of one of nine steps from this balanced mixture. Using the soil samples, have the students feel and discuss the soil texture of each sample. Refer to PPt 4 as well.* ☐ PPt 3 – Textural Triangle ☐ PPt 4 – The Soil Triangle	**Explain what the different soil textures are and how they are determined.** 1. Textural names give clues as to the soil's combinations of the three major separates (sand, silt, and clay), as well as clues to its position on the soil triangle. a. Sand b. Loamy sand c. Sandy loam d. Sandy clay loam e. Clay loam f. Loam: contains all three separates though slightly less clay g. Silt h. Silt loam i. Silty clay loam j. Clay k. Sandy clay l. Silty clay 2. Laboratory analysis shows exact percentages of sand, silt, and clay. Mark points on the soil triangle corresponding with the percentage of at least two soil separates. 3. Field estimates are determined by working the soil between the thumb and fingers to estimate the amounts of sand, silt, and clay by the feel and behavior of the soil. a. First estimate the percentage of sand by noting grittiness. – More than 50% sand: textural name contains the word sand – Less than 20% sand: textural name usually contains the word silt

Instructor Directions	Content Outline
	b. Next, estimate the percentage of clay by the length of ribbon formed. – More than 40% clay: name usually contains only the word clay – Between 27% clay and 40% clay: name contains both the words clay and loam – Below 27% clay: textural name doesn't contain the word clay – Assume the rest of the content is silt
Objective 4 *Discuss rock fragments found in local soils.*	**Explain what rock fragments are and how they are identified.** 1. Rock fragments include all fragments larger than 2 mm. a. Gravel: rounded rock fragments with a diameter between 2 mm and 7.5 cm (3 inches) b. Cobbles: rounded or partly rounded with diameters from 3 inches to 10 inches c. Channer: more flat than round with diameters from 2 mm to 13 cm (6 inches) in length d. Flagstones: more flat than round with diameters from 6 inches to 15 inches in length e. Stones and boulders: round fragments more than 10 inches in diameter and flat fragments larger than 15 inches, considered a site characteristic (See Lesson 11.) 2. Textural names based on fine earth must be modified if soil contains a significant amount of gravel, cobbles, channers, or flagstones. 3. Modifier names depend on the volume of the soil mass occupied by rock fragments. (See Figure 4.2 in the student reference.) a. The percentage of rock fragments by volume is estimated to be equal to the percentage of rock fragments on the surface of a vertical soil profile. b. If a soil contains both gravel and cobbles, at least 60% of the rock fragments must be gravel to use the term gravelly. c. Use the term cobbly if more than 40% of the rock fragments are cobbles. d. Use the same calculations for channers or flagstones.

Instructor Directions	Content Outline
Objective 5 *Discuss how soil texture affects the distribution of pore space.*	**Explain the term pore space.** 1. Pore space is the space between soil particles. 2. Pore space contains either air or water. 3. The A horizon contains about equal amounts of solids and pore space. 4. The B and C horizons usually contain more than one-half pore space because of finer soil particles.
Objective 6 *How does pore space (soil porosity) influence water retention in the soil? Discuss pore space as it relates to root penetration.*	**Describe the importance of pore space.** 1. Pore space influences the behavior of soil for maximum plant growth. a. Infiltration b. Percolation c. Available water capacity d. Aeration
Objective 7 *Discuss why it is important to have good balance of particle sizes to incur maximum plant growth.*	**Explain the relationship between soil texture and pore space.** 1. Sandy soil has the largest pore spaces but cannot hold water as it passes, leaving soil droughty. 2. Clayey soil holds too much water in a thin film of hygroscopic water unavailable to plants and does not allow air flow. 3. A balanced soil texture will have a balanced mixture of large and small pores that will have the best soil properties for maximum plant growth. 4. Excessive tillage reduces pore space.
Objective 8 *Discuss physical properties and how they affect soil texture.*	**Describe how other factors are affected by soil texture.** 1. Soil texture affects the shrink-swell potential of a soil. It affects how buildings and highways are designed to prevent damage from cracking. 2. Content of rock fragments affects the load-bearing capacity for construction of roads, buildings, and earthen dams. 3. Soil texture affects soil behavior concerning water. a. Functioning of septic tank filter fields and sewage lagoons b. Affects the available water capacity c. Leaching of pesticides 4. Soil texture affects the tillage of crops.

Instructor Directions	Content Outline
Application AS 1 – Are All Particles the Same Size?	Answers to AS 1: 1. The sample with the most silt 2. The sample with a favorable proportion of sand, silt, and clay. Other activities: 1. Mix silt, sand, and clay particles together. Fill a jar half full from the mixture. Add water, cover with a lid, and shake vigorously. Set aside and allow the particles to settle out for one day. Record how the different particle sizes separated. 2. Each student is asked to bring in a soil sample. Have each student estimate soil texture by feel. Have students trade soil samples for more practice.
Closure/Summary	Soil texture is the percentage by weight of sand, silt, and clay. Soil texture is important to the aspects of soil behavior. Texture affects the amount of water a soil will hold, the rate of water movement through the soil, and the ease of root development. Texture also determines the porosity of a soil, shrink-swell potential, and the bearing capacity for roads, buildings, and dams. Soil texture can be determined by laboratory analysis or by field estimate (working the soil between the thumb and fingers). Textural class names (based on fine earth) are determined using a textural triangle and are modified if the soil contains a significant amount of rock fragments.
Evaluation: Quiz	Answers: 1. b 2. f 3. h 4. j 5. d 6. i 7. g 8. e 9. c 10. a 11. Loam

Course	Agricultural Science II
Unit	Soil Science
Lesson	Soil Structure
Estimated Time	50 minutes

Student Outcome

Explain the importance of soil structure.

Learning Objectives

1. Explain the term soil structure (ped).
2. Explain the importance of soil structure.
3. Describe how soil structures are formed.
4. Identify the different types of soil structural units.
5. Explain the difference between structure grade and type.
6. Explain how soil structure can be improved.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slide
   - ☐ PPt 1 – Types of Soil Structure
2. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
3. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplies & Equipment

- ❑ Soil samples

Supplemental Information

1. Internet Sites
   - ❑ Horizon Properties: Soil Structure. Goddard Space Flight Center, NASA. Accessed May 16, 2008, from http://soil.gsfc.nasa.gov/pvg/prop1.htm.
   - ❑ Soils. Master Gardner, Ohio State University Extension. Accessed May 16, 2008, from http://www.hcs.ohio-state.edu/mg/manual/soil2.htm.
2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.
   - ❑ Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
   - ❑ Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
   - ❑ Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.

- Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
- White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

Use soil samples to demonstrate the different types of structure.

Communicate the Learning Objectives

1. Explain the term soil structure (ped).
2. Explain the importance of soil structure.
3. Describe how soil structures are formed.
4. Identify the different types of soil structural units.
5. Explain the difference between structure grade and type.
6. Explain how soil structure can be improved.

Instructor Directions	Content Outline
Objective 1 *Discuss how soil structure facilitates movement of water.*	**Explain the term soil structure (ped).** 1. Soil structure forms when individual grains of sand, silt, and clay are bound together physically and/or chemically into larger units called peds. 2. A ped is a single unit of soil structure. 3. Peds range in size from 1 mm to 10 cm depending on their shape.
Objective 2 *Discuss the soil samples on display. Which soil sample has good structure and will provide an ideal environment for plant growth?*	**Explain the importance of soil structure.** 1. Soil structure modifies some of the effects of texture on soil behavior by creating relatively large pores. a. Provides for water infiltration b. Provides for good aeration c. Provides for good soil tilth d. Provides an ideal environment for plant root growth 2. Soil structure can be destroyed. a. Over-tilling b. Tilling while soil is wet
Objective 3 *Ask the students why organic matter is essential if you want to maintain good soil structure.*	**Describe how soil structures are formed.** 1. Weathering converts original (structureless) parent material into soil. 2. Soil is loosened and pore spaces are formed when shrinking and swelling occur. a. Wetting and drying b. Freezing and thawing c. Root penetration

Instructor Directions	Content Outline
	3. Organic matter produces cementing agents that bind and stabilize soil into small clumps with definite shapes (aggregates). Soil then resists breakdown.
Objective 4 *Show the students PPt 1 and discuss the different types of soil structure.* ☐ PPt 1 – Types of Soil Structure	**Identify the different types of soil structural units.** Structured 1. Granular a. Roughly spherical b. Usually 1 to 10 mm in diameter c. Common in surface (A) horizons 2. Platy a. Flat peds that lie horizontally b. Most less than 2 cm thick c. Occur mostly in subsurface (E and Bx) horizons 3. Blocky a. Roughly cube-shaped with generally flat surfaces – Angular (sharp edges and corners) – Subangular (rounded edges and corners) b. Sizes from 5 to 50 mm in diameter c. Typical of subsoil (B horizons) d. Formed by expansion and contraction of clay minerals 4. Prismatic a. Peds taller than wide b. Often have 5 sides c. Most common in lower part of subsoil (B and BC horizons) d. Columnar prisms with rounded tops and corners – Found in strongly developed soils – Caused by eluviation (downward movement of material) Compound structures: Large aggregates can be broken into smaller aggregates of a different shape. Unstructured 1. Single grain a. Unit found in very sandy soils b. Each grain acts independently c. Permeability is rapid d. Fertility and available water low

Instructor Directions	Content Outline
	2. Massive a. Compact, coherent soils b. Not separated into peds c. Small pores d. Slow permeability e. Poor aeration
Objective 5 *Demonstrate soil structure by holding a clod of soil in both hands and applying gentle pressure. If the soil breaks easily along a natural plane of weakness, it is breaking into units of soil structure. Discuss the difference between structure grade and type.*	**Explain the difference between structure grade and type.** Structure grade refers to the strength and stability of structural peds. (The ease with which the soil mass breaks into peds and the amount of unaggregated soil that remains indicate the structural grade.) 1. Strong a. Peds are distinct in undisturbed soil b. Peds separate cleanly into whole units when disturbed c. Peds have stable structures d. Peds provide favorable air-water relationship e. Peds have good soil tilth 2. Moderate a. Well formed and evident in undisturbed soil b. Separate into a mixture of whole peds and broken units when disturbed 3. Weak a. Barely observable b. Become broken when disturbed c. Unstable structures d. Readily slake (break down) e. Readily seal (form a crust) f. Slow water movement g. Increase erosion hazard Structure type refers to the shape of the soil peds that are broken out of the soil mass. 1. Granular 2. Platy 3. Blocky 4. Prismatic (columnar) 5. Unstructured (lack of soil peds)

Instructor Directions	Content Outline
Objective 6 *Discuss the advantages of using deep rooted legumes to improve soil structure. Have students suggest other ways to improve soil structure.*	**Explain how soil structure can be improved.** Time 1. Soil structure gets stronger and more distinct 2. It takes several years to improve very weak structures. Residue management 1. Adding organic matter a. Deep rooted legumes b. Barnyard manure c. Green manure crops (plowed under grasses or legumes) 2. Using minimum tillage (or no-till) a. Avoid over-tilling b. Avoid tilling when wet 3. Rotating crops, including hay crops
Application	Other activities: 1. Have students bring in soil samples and observe the difference in structure. 2. Invite the county extension agent or soil conservation representative to visit your class and discuss the importance of soil structure. 3. Use the soil judging pit to examine the structure of the subsoil.
Closure/Summary	Soil structure is important because it modifies some of the effects of texture on soil behavior. Structure is related to water infiltration, aeration, soil tilth, and the environment for plant root growth. The type and grade of soil structure can be determined by observing the soil and gently breaking it apart. Soil structure can be improved by increasing organic matter content, using minimum-tillage or no-till, and applying good residue management. Soil structure is broken down by over-tilling or tilling when the soil is wet.
Evaluation: Quiz	Answers: 1. b 2. d 3. f 4. g 5. h

Instructor Directions	Content Outline
	6. i 7. j 8. e 9. c 10. a 11. b 12. c 13. b

Course	Agricultural Science II
Unit	Soil Science
Lesson	Soil Horizons
Estimated Time	50 minutes

Student Outcome

Describe a soil profile.

Learning Objectives

1. Explain the term pedon.
2. Explain the term soil profile.
3. Describe a master soil horizon.
4. Explain what horizon boundaries are.
5. Describe transitional horizons.
6. Describe the subordinate divisions of master horizons.
7. Describe the subdivisions of thick horizons.
8. Explain lithologic discontinuities.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - ☐ PPt 1 – Soil Pedons: How They Relate to Landscape
   - ☐ PPt 2 – Master Horizons
   - ☐ PPt 3 – Transitional Horizons
2. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
3. *Soil Science Curriculum Enhancement*. University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplies & Equipment

- ❑ Soil monoliths

Supplemental Information

1. Internet Sites
   - ❑ A Soil Profile. USDA Natural Resources Conservation Service. Accessed May 16, 2008, from http://soils.usda.gov/education/resources/K_12/lessons/profile/.
   - ❑ Francek, Mark. *Soil Horizons*. Science Education Resource Center, Carleton College, Northfield, Minnesota; and Central Michigan University, Mount Pleasant. Accessed May 16, 2008, from http://serc.carleton.edu/NAGTWorkshops/visualization/collections/soil_horizons.html.

2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.
   - ❑ Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
   - ❑ Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
   - ❑ Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
   - ❑ Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
   - ❑ White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

Use soil monoliths for observing the different horizons.

Communicate the Learning Objectives

1. Explain the term pedon.
2. Explain the term soil profile.
3. Describe a master soil horizon.
4. Explain what horizon boundaries are.
5. Describe transitional horizons.
6. Describe the subordinate divisions of master horizons.
7. Describe the subdivisions of thick horizons.
8. Explain lithologic discontinuities.

Instructor Directions	Content Outline
Objective 1 *Arrange a field trip to observe how different soils are formed. Show slides of soil profiles or actual soil profiles so the students may observe the factors in soil formation. Discuss how soil horizons are formed. Discuss how a soil pedon is formed. Use PPt 1 to illustrate #2.* ☐ PPt 1 – Soil Pedons: How They Relate to Landscape	**Explain the term pedon.** 1. The smallest volume that can be called "soil" is a pedon. 2. A pedon is three-dimensional and large enough to permit study of all horizons. 3. The area of a pedon may vary from 10 to 100 square feet (1 square meter to 10 square meters) depending on how much the soil changes.
Objective 2 *Have students observe the several soil profiles. Point out the different soil horizons until the students can identify the horizons themselves. Display PPt 2 to show the master horizons.* ☐ PPt 2 – Master Horizons	**Explain the term soil profile.** 1. A soil profile is a vertical section of a soil pedon from the surface through all of its horizons including parent material. 2. A single soil profile never has all the horizons that are possible.
Objective 3 *Discuss the six master horizons. Discuss management strategies as*	**Describe a master soil horizon.** 1. A soil horizon is a layer of soil parallel to the earth's surface.

Instructor Directions	Content Outline
they relate to different soils. Refer to PPt 2 to illustrate the six master horizons. ☐ PPt 2 – Master Horizons	2. A master soil horizon is one of the six general kinds of horizons that occur in soil profiles with a distinct set of properties. 3. Each is named with capital letters: O, A, E, B, C, or R. a. O Horizon (O = organic) – This horizon has a layer of organic debris. – O horizons are nearly 100% organic matter material. – Forest soils have thin organic horizons. – Wet soils in bogs or drained swamps often have O horizons of peat or muck. – Most soils in Missouri have only thin O horizons. – O horizons are destroyed by plowing and do not occur in cultivated areas. b. A Horizon – Surface horizon of mineral soil – Usually dark color from the accumulation of humus – Thickness ranges from a few inches (most forested soils) to over 30 inches (some upland prairie soils and some alluvial soils in flood plains) – Every cultivated agricultural soil has an A horizon – Extremely important in maintaining soil fertility and providing a favorable environment for root growth c. E Horizon (E = eluviation) – Strongly leached horizon – Occurs immediately beneath an O or an A horizon – Grayish-brown to white in color; nearly all the iron and organic matter removed – Occurs in most forested soils that have not been cultivated and in several of the prairie soils in Missouri – Contains noticeably less clay than the B horizon beneath it d. B Horizon – The subsoil layer that generally changes the most because of soil-forming processes

Instructor Directions	Content Outline
	– Has the brightest yellowish-brown or reddish-brown colors – Has more clay than other horizons – Clay films visible e. C Horizon: Weathered unconsolidated geologic material below the A or B horizon. Anything that is soft enough to dig with a spade but which has not been changed very much by soil-forming processes is considered C horizon. f. R Horizon (R = rock): Hard bedrock that you cannot dig with a spade
Objective 4 *Discuss what horizon boundaries are. Use sample profiles or judging pits to illustrate horizon boundaries.*	**Explain what horizon boundaries are.** 1. A horizon boundary is the division line between two distinct horizons, where one horizon ends and the other begins. 2. Terms used to describe boundary distinctness and the nature of the boundary may provide clues to soil development and behavior. a. **Abrupt:** boundary is less than 1 inch (2.5 cm) wide – Sudden change to another kind of material or texture – May limit root penetration – May signal a different rate of water movement b. **Clear:** boundary is 1 to 2.5 inches (2.5 to 6 cm) wide c. **Gradual:** boundary is 2.5 to 5 inches (6 to 12.5 cm) wide, may indicate very young or highly weathered old soil d. **Diffuse:** boundary is more than 5 inches (12.5 cm) wide 3. The form or shape of horizon boundaries requires careful examination to determine the true relationship between soil horizons. a. **Smooth:** nearly a plane b. **Wavy:** shallow pockets wider than their depth c. **Irregular:** pockets deeper than their width d. **Broken:** parts of the horizon unconnected with other parts

Instructor Directions	Content Outline
Objective 5 *Discuss what transitional horizons are. Talk about how soils have formed in more than one kind of parent material. Discuss how a flooding river deposits fresh silt on top of older sands and gravels. Refer to PPt 3.* ☐ PPt 3 – Transitional Horizons	**Describe transitional horizons.** 1. Areas between master horizons where changes occur gradually throughout a zone that may be 5 or 10 inches thick. 2. Transitional horizons are named with two letters, three of which are common in Missouri soils a. AB horizon – This occurs between the A and B master horizons with dominant A properties, but some properties of the B are evident. – Dark colors associated with organic matter are fading because organic matter is decreasing. – Structure often changes from granular to subangular blocky. b. BA horizon – This also occurs between the A and B, but it has more characteristics of the B. – Structure will generally be the same type as the B, but less strongly expressed. – Colored darker than the B or the clay content may be less than the maximum in the B. c. BC horizon – This horizon has a transition from the B to C with dominant B horizon properties, but some influence of the C horizon is evident. – Often the clay content will be less than the maximum in the B, but more than in the C, or the color will be fading. – The C is massive, and the BC has structure, but it may have larger units and more weakly expressed than the B.
Objective 6 *Have students observe profiles and assist them in determining subordinate distinctions in each horizon. Discuss what the subordinate divisions of master horizons are.*	**Describe the subordinate divisions of master horizons.** Subordinate divisions of master horizons are horizons resulting from unique processes that leave a distinct mark on the horizon. Subordinate divisions within master horizons are named by adding lowercase letters immediately following the master horizon symbol. Over 25 letters and combinations of letters are possible.

Instructor Directions	Content Outline
	Eight subordinate divisions are common in Missouri. 1. Oi horizon: The organic layer covering the A horizon with a layer of slightly decomposed twigs and leaves 2. Ap horizon (p = plow layer) a. The surface horizon of soil in which cultivation has mixed the upper 8 to 12 inches and destroyed natural horizons b. Plowing an exposed B or C horizon would automatically make the surface horizon an Ap 3. Bt horizon (t = translocated clay) a. Has distinctly more clay than the horizons above or below it b. Clay usually moved from horizons above by water carrying fine clay particles with it c. Clay possibly coming from the weathering of original minerals in the Bt horizon d. Has well-developed blocky or prismatic structure 4. Bg horizon (g = gleyed) a. Horizon gleyed (wet for long periods of time); indicates poorly drained soil b. Iron chemically reduced by leaching leaving soil dark gray c. Not restricted to Bg; other gleyed horizons: the Ag, Eg, BAg, BCg, and Cg 5. Bw horizon (w = weathered) a. This horizon has been changed by weathering, but not enough to form a Bt or Bg b. In Missouri soils, the Bw differs from the C by having weak or moderate blocky structure c. The Bw may also have a brighter color and it may be more leached than the C d. Bw horizons are common in young soils of flood plains and low stream terraces 6. Bx horizon a. This refers to a fragipan b. Horizon is a massive, dense, but not cemented soil horizon c. It is often mottled and has seams of gray silt scattered throughout. d. The fragipan is so dense that neither plant roots nor water can readily penetrate, except in the gray silt seams.

Instructor Directions	Content Outline
	e. In Missouri, fragipans occur mostly in gently sloping upland soils and some high terrace soils in southern Missouri 7. Bk horizon a. This horizon has an accumulation of calcium carbonate, or free lime, leached from upper horizons and redeposited in the Bk b. White streaks or nodules of lime are visible and can be tested with hydrochloric acid (HCl) c. Use the k only to indicate horizons enriched in visible deposits of carbonates by translocation (not for soils on the Missouri River flood plain and uplands of northwest Missouri that have free lime in original amounts) 8. Cr horizon (r = bedrock) a. Weathered bedrock, or rock that is soft enough to slice with a knife or spade b. Original rock structure is often visible c. Not hard enough to be designated R
Objective 7 *Discuss what subdivisions of thick horizons are.*	**Describe the subdivisions of thick horizons.** 1. Very thick master horizons or subordinate divisions need to be classified into special subdivisions 2. Vertical sequences within any single horizon indicated by small changes in texture, color, or structure 3. Indicated by using Arabic number, as in A1, A2, or Bw1, Bw2, and Bw3
Objective 8 *Observe soil horizons to see if they are developed in more than one material. Discuss what lithologic discontinuities are.*	**Explain lithologic discontinuities.** 1. Soil horizons developed in more than one parent material 2. Indicated by a number placed in front of the horizon name showing its position from the top down a. The geologic material at the surface is always assumed to be the first one, so the number 1 is never used. b. The second geologic material is indicated by a 2, the third by a 3, and so on. c. An example of soil developed in silt over gravel could have the following set of horizons: A-AB-B-2BC-2C.

Instructor Directions	Content Outline
Application	Other activities: 1. Study the history of the soils in your vicinity and state. 2. Prepare a soil pit and have students determine the soil horizons.
Closure/Summary	The smallest volume that can be called "soil" is a pedon. A soil profile is a vertical section of a soil pedon beginning at the surface and continuing down through all of the horizons, including the parent materials. Six master horizons may occur in soil profiles. The distinctness of boundaries, special features of horizons, subdivisions of thick horizons, and lithologic discontinuities further define the soil horizons.
Evaluation: Quiz	Answers: 1. e 2. a 3. i 4. c 5. g 6. d 7. j 8. b 9. f 10. h 11. b 12. d 13. f 14. e 15. c 16. a

Course	Agricultural Science II
Unit	Soil Science
Lesson	Soil Chemical Properties
Estimated Time	50 minutes

Student Outcome

Explain how plants exchange anions for cations.

Learning Objectives

1. Explain the importance of cation exchange capacity (CEC).
2. Explain what CEC is.
3. Explain how CEC is calculated.
4. Identify the soil properties which affect CEC.
5. Explain what soil pH is.
6. Explain how pH relates to productivity.
7. Explain the factors which cause pH to change.
8. Explain how soil pH can be adjusted.

Grade Level Expectations

SC/ME/1/B/09-11/b SC/ME/1/E/09-11/a SC/ME/1/E/09-11/c

SC/ME/1/F/09-11/c

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - ☐ PPt 1 – Negatively Charged Clay Particle (Micelle)
   - ☐ PPt 2 – pH Scale
   - ☐ PPt 3 – How Soil pH Governs Nutrient Release
2. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
3. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplemental Information

1. Internet Sites
   - ❑ Chemical Properties of Soil. Tree Fruit Soil and Nutrition, Tree Fruit Research and Extension Center, Washington State University. Accessed May 16, 2008, from http://soils.tfrec.wsu.edu/mg/chemical.htm.
   - ❑ Soils Basics: Part II – Chemical Properties of Soil. University of Massachusetts Extension. Accessed May 16, 2008, from http://www.umassvegetable.org/soil_crop_pest_mgt/soil_nutrient_mgt/soil_basics_II.html.
   - ❑ Soil and Water Publications. University of Missouri Extension. Accessed May 16, 2008, from http://extension.missouri.edu/explore/agguides/soils/.

2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.
   - ❑ Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
   - ❑ Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
   - ❑ Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
   - ❑ Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
   - ❑ White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

Why are some soils more productive than others? Use the bank account approach to illustrate this. As the plants grow they draw checks from the bank. Thus, if the total amount of calcium carbonate (lime) in the soil was 1200 lbs per acre and if alfalfa removed 120 lbs each year, there would be enough lime to last 10 years.

Communicate the Learning Objectives

1. Explain the importance of cation exchange capacity (CEC).
2. Explain what CEC is.
3. Explain how CEC is calculated.
4. Identify the soil properties which affect CEC.
5. Explain what soil pH is.
6. Explain how pH relates to productivity.
7. Explain the factors which cause pH to change.
8. Explain how soil pH can be adjusted.

Instructor Directions	Content Outline
Objective 1 *Ask students why soils with high CEC (cation exchange capacity) are more fertile than low CEC soils. Discuss the importance of soil chemistry and its effect on crop yields.*	**Explain the importance of cation exchange capacity (CEC).** 1. Soil chemistry has a significant effect on crop yields. 2. Soil chemistry involves the relationship between clay minerals, water, and other elements in the soil. 3. Quantity and balance of nutrient elements are important factors in soil fertility. 4. CEC of the soil determines what amounts of plant nutrients are needed.
Objective 2 *Use PPt 1 to illustrate how cations are exchangeable. Use magnets to reinforce the fact that like charges repel. Discuss how this compares to soil's capacity to hold essential nutrients.* ☐ PPt 1 – Negatively Charged Clay Particle (Micelle)	**Explain what CEC is.** 1. CEC is the soil's capacity to hold and exchange essential cations. Oxygen, silicon, and aluminum make up about 85% of the earth's crust, and greatly affect the CEC of the soil. 2. Essential soil elements are made up of atoms. Atoms are the smallest portion of an element that can take part in a chemical reaction. 3. Atoms that have become electrically charged are called ions. a. Postively charged ions are called cations. b. Negatively charged ions are called anions. c. Ions usually have from one to four positive or negative charges. 4. In chemical systems, there is always an equal balance of positive and negative charges.

Instructor Directions	Content Outline
	a. For example, two positively charged hydrogen ions attract one oxygen ion, which has two negative charges. b. Negatively charged clay minerals attract and hold positively charged ions of elements. c. The phenomenon of cations being attracted and held by the soil particle surfaces is called adsorption. 5. Bases tend to make the soil alkaline (Ca^{++}, Mg^{++}, K^{+}, and Na^{+}). 6. Acid cations tend to make the soil acidic (H^{+} and Al^{+++}). 7. The very small soil particles are not ions but have several negative charges per particle. a. Micelle is a term used for a negatively charged solid particle composed of clay or organic matter. b. Colloid is a term used to describe clay particles. c. Water surrounding micelles contains many positive charges. 8. Cation exchange is the process of micelles and plant roots exchanging ions. a. Micelles exchange acid H^{+} ions for Ca^{++}, Mg^{++}, and K^{+} base ions. The chemical attraction of the bases is much greater than the attraction of hydrogen H^{+} ions. b. Plant roots exchange H^{+} acid ions for Ca^{++}, Mg^{++}, and K^{+} base ions. These bases are some of the most important plant nutrients.
Objective 3 *Have students use the soil test data to calculate the CEC of the soil and determine the amount of fertilizer needed. Use Tables 7.1, 7.3, 7.4, and 7.5 of the student reference to assist in explaining and figuring CEC of the soil.*	**Explain how CEC is calculated.** 1. Obtain the results of a soil test. Soil contains various amounts of each of the exchangeable cations. 2. Add the milliequivalent weights of only K, Mg, Ca (bases) with H and Al (neutralizable acids or NA). a. Determine how many grams of each cation are contained in 100 g of soil (milliequivalent) by dividing its atomic weight by the number of positive charges on each ion. b. Calculations used in determining the CEC are based on the upper 7 inches of the surface layer of earth (which weighs about 2,000,000 lbs per acre).

Instructor Directions	Content Outline
	3. CEC is the total of these cations in milliequivalents. The sum of the bases divided by the total sum of the cations is the percent of base saturation.
Objective 4 *Discuss how texture affects the exchange capacity of the soil. Discuss the importance of organic matter in the exchange capacity of the soil.*	**Identify the soil properties which affect CEC.** 1. Amount of clay a. Low clay content indicates low CEC (sand or sandy loam). b. High clay content indicates high CEC. 2. Kind of clay: Montmorillonite clay has a larger CEC than kaolinite. 3. Organic matter content: Average organic matter content has medium CEC (loam and silt loam). 4. Textural differences a. Severely eroded soils have more clay and a higher CEC. – Contain less organic matter – Poorer tilth – Lower available water capacity b. Organic matter has good exchange capacity. – Soils containing 4% organic matter may have as much as 8 meq per 100 g of soil. – Silt loam with high organic matter content is most ideal. – Loam and silt loam have a high available water capacity.
Objective 5 *Have students discuss the meaning of pH. Refer to PPt 2 as pH is discussed.* ☐ PPt 2 – pH Scale	**Explain what soil pH is.** 1. pH is a scale from 0 to 14 that measures acidity to alkalinity. The pH increases 10 times between each unit of the scale. 2. Neutral pH of 7 on the scale is neither acid nor alkaline. It occurs when the concentration of H^+ ions and OH^- ions are equal (in pure water at 75° F). a. Pure water at 75° F contains 1.0×10^{-7} g of H^+ or 0.0000001N. b. The pH scale simplifies the -7 exponent to pH 7. 3. Acid or lower pH occurs when the concentration of H^+ ions increases. 4. Alkaline or higher pH occurs when the concentration of OH^- ions increases.

Instructor Directions	Content Outline
	5. Two methods are used to determine soil pH a. Water pH (pH_w): a measure of the H^+ ions in the soil solution and the H^+ ions that were attached to soil particles. b. Salt pH (pH_s) – More precise method – About 1/2 unit lower than water pH – Reflection of neutralizable acidity (NA) – Calcium chloride releases the H^+ ions from the soil particles so they can be measured
Objective 6 *Discuss the effect of pH on plants. Ask the students how pH affects the nutrient availability of soil. Discuss the relationship of pH and soil organisms. Use PPt 3 to illustrate the pH range in which crops will grow best.* ☐ PPt 3 – How Soil pH Governs Nutrient Release	**Explain how pH relates to productivity.** 1. Soil pH governs relative nutrient availability. It indicates balance between plant nutrient elements (K, Mg, and Ca) and non-nutrient elements (H and Al). 2. Strongly acidic soils have low amounts of CEC occupied by K, Mg, and Ca. 3. Soil pH, CEC, and the neutralizable acidity (NA) value indicate the need for agricultural lime (Ca) for a particular crop. a. Legumes require more neutral soils of pH_w 6.8–7.3. b. Corn, small grain, and grass need pH_w of 6.0–6.8. c. Blueberries require acid soil to grow best. d. Trees grow better in soils below pH_w of 7.0. 4. Soil pH_w may also change the effect of pesticides and herbicides may become overactive and burn crops.
Objective 7 *Discuss with the students the factors that change soil pH.*	**Explain the factors which cause pH to change.** 1. Depletion of Ca causes increased acidity 2. Leaching – removal of bases by water 3. Absorption – removal of bases by growing plants
Objective 8 *Discuss with the students how pH can be adjusted by adding Ca back into the soil through the use of lime.*	**Explain how soil pH can be adjusted.** 1. Lime application can raise soil pH to a desirable level. a. Lime causes the H^+ on micelles surface to be replaced by Ca^{++}.

Instructor Directions	Content Outline
	– H^+ and CO^3 ions form carbonic acid, which further breaks down to carbon dioxide gas and water. b. Lime helps release other non-base plant nutrients.
Application	Other activities: 1. Use pH paper to test a number of household solutions, such as tap water, ammonia, vinegar, and lemon juice. 2. Check a soil sample for pH by mixing 20 g of soil with 20 ml of distilled water. Mix the sample well and let stand for 15 minutes. Use pH paper to determine the pH. 3. Place a few drops of a strong acid on a piece of limestone rock and observe the fizz. Discuss this reaction with the students. 4. Perform a cation exchange experiment. Place a filter paper in a funnel, add several grams of soil, then pour a solution of ammonium acetate through the soil. Catch the filtrate in a container and run a test for magnesium, calcium, potassium, sodium, and hydrogen. The filtrate should contain at least traces of all the cations. The ammonium acetate replaced the calcium, magnesium, potassium, sodium, and hydrogen ions on the surface of the clay crystals and humus particles. These cations were released to the soil solution and were moved down into the filtrate. 5. Have students bring in actual soil tests for CEC evaluation.
Closure/Summary	Soil chemistry and the cation exchange capacity (CEC) are important to crop yields. Soil chemistry involves the relationship between minerals, water, and other soil elements. CEC is the soil's capacity to hold and exchange essential nutrients with plants. The surfaces of clay minerals attract and hold positively charged ions, called cations, in exchange for negatively charged ions, called anions. Soil pH gives an estimate of the balance between plant nutrient elements (bases) and non-nutrient elements (acids). The two kinds of soil tests for pH are water (pH_w) and salt (pH_s). The pH values indicate the need for agricultural lime, but the exact quantity required is a function of CEC. Each crop has its own level

Instructor Directions	Content Outline
	of pH for good production. After nutrients have been used by plants, they need to be replenished by fertilization to maintain a high level of production.
Evaluation: Quiz	Answers: 1. b 2. c 3. i 4. e 5. g 6. d 7. h 8. f 9. a 10. K = 0.5 11. Mg = 1.5 12. Ca = 6.0 13. NA = 4.0 14. Total CEC = 12 15. K = 240 16. Mg = 288 17. Ca = 3600 18. No additional K needed 19. No additional Mg needed 20. 1200 lbs/A of additional Ca is needed

Course	Agricultural Science II
Unit	Soil Science
Lesson	Soil Fertility
Estimated Time	Two 50-minute blocks

Student Outcome

Identify what plants get from the soil to be healthy and what gives them maximum yields.

Learning Objectives

1. Identify a plant's essential macronutrients.
2. Explain the macronutrients' primary functions for plant growth.
3. Explain the hunger signs which can be observed in crops that lack the major elements.
4. Identify a plant's essential micronutrients.
5. Explain the importance of organic matter.
6. Identify the major nutrients supplied by organic matter.

Grade Level Expectations

SC/ES/1/B/09-11/a

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - ☐ PPt 1 – Nitrogen Cycle
   - ☐ PPt 2 – Contents of a Bag of Fertilizer
2. Activity Sheet
   - AS 1 – How Organic Matter Builds Soil Structure
3. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
4. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplies & Equipment

- ❑ See AS 1 for materials and equipment needed to complete the Activity Sheet.

Supplemental Information

1. Internet Sites
   - ❑ Hodges, Steven C. Soil Fertility Basics: NC Certified Crop Advisor Training. Soil Science Extension, North Carolina State University. Accessed May 19, 2008, from http://www.soil.ncsu.edu/nmp/Nutrient%20Management%20for%20CCA.pdf.
   - ❑ Nutrient Deficiency Symptoms. Back-to-Basics Soil Fertility Information, The Mosaic Co., Plymouth, MN. Accessed May 19, 2008, from http://www.back-to-basics.net/.
   - ❑ Nutrient Deficiency Symptoms. K-MAG, The Mosaic Co., Plymouth, MN. Accessed May 19, 2008, from http://www.kmag.com/general/nds.htm.

- ❑ Soil Fertility. Agronomy Extension, Iowa State University. Accessed May 19, 2008, from http://www.agronext.iastate.edu/soilfertility/.

2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.
   - ❑ Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
   - ❑ Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
   - ❑ Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
   - ❑ Plaster, J. Edward. *Soil Science and Management*. 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
   - ❑ White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

Show examples of fertilizer grades, rations, and formulations. Take students to visit a fertilizer manufacturer if possible or invite a sales person to speak to the class.

Communicate the Learning Objectives

1. Identify a plant's essential macronutrients.
2. Explain the macronutrients' primary functions for plant growth.
3. Explain the hunger signs which can be observed in crops that lack the major elements.
4. Identify a plant's essential micronutrients.
5. Explain the importance of organic matter.
6. Identify the major nutrients supplied by organic matter.

Instructor Directions	Content Outline
Objective 1 *What is a fertile soil? Discuss the 17 elements necessary for plant growth.*	**Identify a plant's essential macronutrients.** There are 9 essential macronutrients (out of 17 elements necessary for plant growth). 1. Three are supplied by water and air. a. Carbon (C) b. Hydrogen (H) c. Oxygen (O) 2. Six are available in the soil. a. Available mainly in mineral solids – Calcium (Ca) – Magnesium (Mg) – Potassium (K) b. Available in mineral solids and organic matter – Phosphorus (P) – Sulfur (S) c. Available primarily in organic matter – Nitrogen (N)
Objective 2 *Discuss the primary functions of each macronutrient for adequate plant growth. Refer to PPt 1 when discussing nitrogen.* ☐ PPt 1 – Nitrogen Cycle	**Explain the macronutrients' primary functions for plant growth.** 1. Nitrogen (N) a. Nitrogen provides critical elements for plant growth. – Needed for photosynthesis – Needed for plant and root cells – Needed for dark green, lush growth b. Many compounds in plants contain nitrogen. – Amino acids – Enzymes

Instructor Directions	Content Outline
	– Chlorophyll a. Soils need nitrogen to produce crops. – Helps the breakdown of organic material – Needed by microbes to decompose matter 2. Phosphorus (P) a. A component of every living cell b. Concentrated in seeds and growing parts of plants c. Needed for root development d. Aids in the maturing of crops 3. Potassium (K) a. Helps in the uptake of other nutrients b. Assists in enzyme systems affecting metabolism and photosynthesis c. Helps regulate the opening and closing of stomata in the leaves d. Important in the formation of carbohydrates e. Helps regulate the uptake of water in the root cells f. Important for strong brace roots 4. Calcium (Ca) a. Exchangeable calcium aids in the availability of other elements b. Essential for building cell walls, new roots, and leaves 5. Magnesium (Mg) a. Chlorophyll contains magnesium, which is vital in the photosynthesis process. b. Magnesium is contained in the seed. 6. Sulfur (S) a. Sulfur is a vital part of all plant proteins and some hormones.
Objective 3 *Discuss why more soils are likely to be deficient in nitrogen, phosphorus, and potassium. Discuss the fertilizer 12-12-12 and explain its meaning using PPt 2.* ☐ PPt 2 – Contents of a Bag of Fertilizer	**Explain the hunger signs which can be observed in crops that lack the major elements.** 1. Nitrogen deficiency symptoms a. Pale green color and poor growth and shortage of chlorophyll are evident. b. Leaves may turn yellow and die during extended dry periods. c. Crop residue will not decompose within a year. d. Soil will not produce. 2. Phosphorus deficiency symptoms

Instructor Directions	Content Outline
	a. Stunted growth b. Late maturity c. Purple spots and streaks in leaf tissues indicate excess sugar caused by slow conversion to starch and cellulose. 3. Potassium deficiency symptoms a. Edges and areas between veins on older leaves turn yellow, then brown. b. Small brown spots develop while the veins remain green. c. Brace roots may not fully develop.
Objective 4 *Discuss how micronutrients or trace elements may affect the process of chlorophyll development.*	**Identify a plant's essential micronutrients.** 1. The eight micronutrients are trace elements found in the soil that are essential to plant health. a. Boron (B) b. Chlorine (Cl) c. Copper (Cu) d. Iron (Fe) e. Manganese (Mn) f. Molybdenum (Mo) g. Cobalt (Co) h. Zinc (Zn) 2. Other elements such as sodium (Na) are absorbed but are not essential micronutrients.
Objective 5 *Compare two soil samples, one high in organic matter and the other low in organic matter. Discuss the importance of organic matter in the soil. After this discussion, have students complete AS 1.* AS 1 – How Organic Matter Builds Soil Structure	**Explain the importance of organic matter.** 1. Improves soil structure a. Enhances aeration b. Enhances healthy root development 2. Adds to the total CEC of the soil 3. Supplies essential nutrients
Objective 6 *Discuss the decomposition of organic matter. Discuss ways to maintain organic matter in the soil.*	**Identify the major nutrients supplied by organic matter.** 1. Supplies most of the naturally occurring nitrogen in soil 2. Accounts for about half of the phosphorus found in soil

Instructor Directions	Content Outline
Application AS 1 – How Organic Matter Builds Soil Structure	Answers to AS 1: 1. The cultivated field has a higher percent of organic matter and improved the soil tilth. This helps soil hold water and therefore decreases the amount of water runoff. 2. The undisturbed fence row is low in organic matter. Other activities: 1. Grow nutrient-deficient plants as a class project. Make note of the deficiency symptoms observed. Use construction sand as the growing media as it contains fewer nutrients. Plant several inch-tall seedlings of corn, beans, and tomatoes into moist sand in individual pots. Fertilize them with water-soluble fertilizer. Each pot should receive all the elements except the nutrient you choose to be deficient. 2. Show a slide series of plant deficiency problems. 3. Have students research newspaper articles citing nutrient deficiencies in crops planted on land damaged by recent flooding or a hurricane.
Closure/Summary	A fertile soil produces high-yielding, healthy crops. Although a fertile soil has nutrient balance and quantity, nutrients alone are not sufficient to make a soil fertile. Fertile soil depends on soil texture, structure, root depth, organic matter content, available water capacity, aeration, length of growing season, and physical support.
Evaluation: Quiz	Answers: 1. b 2. a 3. e 4. c 5. d 6. i 7. j 8. h 9. g 10. f

Course	Agricultural Science II
Unit	Soil Science
Lesson	Soil Sampling and Interpreting Soil Test Results
Estimated Time	Two 50-minute blocks

Student Outcome

Prepare a soil sample for analysis.

Learning Objectives

1. Explain why soil samples are taken.
2. Identify the factors which influence the number of samples that are taken.
3. Identify when and how often a soil sample should be taken.
4. Explain the procedure which should be followed to obtain a good soil sample.
5. Explain how to take a soil sample for a cultivated field, no-till field, and a lawn or garden.
6. Identify some pitfalls to avoid when obtaining a good soil sample.
7. Identify what soil testing services are locally available.
8. Explain why information about crop history should be included with the soil sample.
9. Identify what data can be obtained from a soil test report.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - ☐ PPt 1 – Methods of Taking a Soil Sample
   - ☐ PPt 2 – Taking a Soil Sample from a Cultivated Field
2. Activity Sheet
   - AS 1 – Take a Soil Sample
3. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
4. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplies & Equipment

- ❑ Obtain Soil Sample Information sheets for each student from Extension's website or refer to the example in AS 1. See AS 1 for materials and equipment needed to complete the Activity Sheet.

Supplemental Information

1. Internet Sites
   - ❑ Soil Sample Information Sheet for Field Crops. University of Missouri Extension. Accessed May 19, 2008, from http://extension.missouri.edu/explorepdf/miscpubs/MP0188.pdf.

- ❑ Soil Test Interpretation Guide. Oregon State University Extension Service. Accessed May 19, 2008, from http://extension.oregonstate.edu/catalog/pdf/ec/ec1478.pdf.
- ❑ Soil Testing. Home and Garden Information Center, Clemson University Cooperative Extension Service. Accessed May 19, 2008, from http://hgic.clemson.edu/factsheets/hgic1652.htm.

2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.
   - ❑ Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
   - ❑ Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
   - ❑ Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
   - ❑ Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
   - ❑ White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

Discuss why soil tests are important. Compare the analysis of a soil test to your doctor taking your blood pressure and reading your x-rays. Obtain actual Soil Sample Information sheets for each student from Extension's website or refer to the example in AS 1 for this lesson. Review this form with the students to gain clues as to proper soil sample collecting procedures.

Communicate the Learning Objectives

1. Explain why soil samples are taken.
2. Identify the factors which influence the number of samples that are taken.
3. Identify when and how often a soil sample should be taken.
4. Explain the procedure which should be followed to obtain a good soil sample.
5. Explain how to take a soil sample for a cultivated field, no-till field, and a lawn or garden.
6. Identify some pitfalls to avoid when obtaining a good soil sample.
7. Identify what soil testing services are locally available.
8. Explain why information about crop history should be included with the soil sample.
9. Identify what data can be obtained from a soil test report.

Instructor Directions	Content Outline
Objective 1 *Evaluate the importance of a soil test. Discuss why we should have a soil test made after each crop.*	**Explain why soil samples are taken.** 1. To produce healthy, high-yielding plants at minimal cost 2. To determine the percentage of the organic matter 3. To determine the pH 4. To determine the amount of available nutrients in the soil
Objective 2 *Explain why it is necessary to limit the number of acres included in the soil test. Refer to Figure 9.1 of the student reference.*	**Identify the factors which influence the number of samples that are taken.** 1. Size of the area to sample (20 acres or fewer) 2. Areas of different soil 3. Areas growing different crops 4. Various surface textures 5. Eroded areas 6. Wet areas
Objective 3 *Discuss how often a soil test should be made and what time of year is the best for taking a soil sample?*	**Identify when and how often a soil sample should be taken.** 1. Can be taken at any time of the year 2. When soil is dry enough to till or is slightly wet – not when soil is muddy 3. Retest every 3 to 4 years

Instructor Directions	Content Outline
Objective 4 *Demonstrate the proper procedure for taking a soil sample. Use PPt 1 to discuss soil sampling techniques. Have students complete AS 1. Explain why it is necessary to include the top 7 inches of soil. Refer to Figure 9.1 of the student reference.* ☐ PPt 1 – Methods of Taking a Soil Sample AS 1 – Take a Soil Sample	**Explain the procedure which should be followed to obtain a good soil sample.** 1. Use a soil auger, probe, or spade. 2. Include the top 7 inches of soil in each subsample. 3. Samples should be taken from different areas of the field and mixed thoroughly. 4. Place about a quart of the sample material in a small box or bag. 5. Identify each sample by field number and field map. 6. Air-dry sample in a dust-free area. 7. Take the sample to local University Extension Center for analysis.
Objective 5 *Discuss how to sample soils correctly. Ask students what problems they have in taking a soil sample from a cultivated field. Refer to PPt 2.* ☐ PPt 2 – Taking a Soil Sample from a Cultivated Field	**Explain how to take a soil sample for a cultivated field, no-till field, and a lawn or garden.** 1. Press freshly cultivated soil down slightly to obtain a natural depth. Take 10-20 subsamples in a cultivated field. 2. Two samples are needed from a no-till field. a. Take 10-20 subsamples from the top 3 inches. b. Take another 10-20 subsamples from the next 4 inches. 3. A garden requires 4-10 subsamples from the top 7 inches of soil.
Objective 6 *Discuss the importance of obtaining a good soil sample. Ask the students what areas to avoid when taking soil samples.*	**Identify some pitfalls to avoid when obtaining a good soil sample.** 1. Do not take samples from areas that are not representative of the entire field. a. Field boundaries, dead furrows, and end rows b. Areas near limestone gravel roads c. Severely eroded areas d. Wet spots e. Old barn lots 2. Do not dry samples by oven or microwave.
Objective 7 *Ask students what soil testing services are available in your area.*	**Identify what soil testing services are locally available.** 1. University Extension Center 2. Fertilizer companies 3. Independent laboratories

Instructor Directions	Content Outline
Objective 8 *Discuss the importance of crop history. Compare your bank account to the soils account for your fields or gardens.*	**Explain why information about crop history should be included with the soil sample.** 1. Helps explain test results 2. Helps in making future crop recommendations
Objective 9 *Discuss an actual soil test for a garden and a cropping field.*	**Identify what data can be obtained from a soil test report.** 1. Percentage of organic matter content 2. pH 3. CEC 4. Calcium 5. Magnesium 6. Phosphorus 7. Potassium 8. Available neutralizable acidity (NA) 9. Available nitrogen is not tested because it is quickly exhausted and replenished as needed for each crop
Application AS 1 – Take a Soil Sample	Answers to AS 1: No questions – students can be graded on participation at the instructor's discretion. Other activities: 1. Invite an agent from University Extension to explain soil test data or tour a soil testing facility. 2. Demonstrate the proper technique in taking a soil sample from a test area. Send the sample to a lab for analysis. Use the data to have the students make recommendations.
Closure/Summary	Soil samples are needed every 3 to 4 years to determine the organic matter content, the pH, and the amount of available nutrients in the soil. Samples should be representative of the field or plot. Ten to 20 subsamples should be taken from large fields when the soil is dry enough to cultivate. Subsamples should be thoroughly mixed together, air-dried, and taken to an independent laboratory.

Instructor Directions	Content Outline
Evaluation: Quiz	Answers: 1. Can be taken at any time of the year. Soil should be dry enough to till. 2. a. Use a soil auger, probe, or spade. b. Include the top 7 inches of soil in each subsample. c. Samples should be taken from different areas of the field and mixed thoroughly. d. Place about a quart of the sample material in a small box or bag. e. Identify each sample by field number and field map. f. Air-dry sample in a dust-free area. g. Take the sample to local University Extension Center for analysis. 3. Crop history helps to explain unusual test results and present nutrient levels. It also helps in making recommendations for future crops. 4. To produce healthy, high-yielding plants at minimal cost by determining the percentage of the organic matter, the pH, and the amount of available nutrients in the soil.

Course	Agricultural Science II
Unit	Soil Science
Lesson	Effects of Soil on Water Movement and Retention
Estimated Time	Two 50-minute blocks

Student Outcome

Evaluate the effects of soil on water.

Learning Objectives

1. Explain the importance of available water to plant growth.
2. Identify the different types of soil waters.
3. Define available water capacity.
4. Explain the effect soil texture has on available water capacity.
5. Explain the effect that effective rooting depth has on available water capacity.
6. Explain the effect rock fragment content has on available water capacity.
7. Identify other factors which affect available water capacity.
8. Explain how available water capacity is determined.
9. Define permeability and identify the soil properties which affect permeability.
10. Identify the factors which affect the internal drainage of soil.
11. Explain how seasonal high water tables are determined.

Grade Level Expectations

SC/FM/2/B/09-11/a	SC/ES/1/B/09-11/a	SC/ES/2/A/09-11/a
SC/ES/2 /A/09-11/b	SC/ES/3/A/09-11/c	

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - ☐ PPt 1 – Water Removal by Plants
   - ☐ PPt 2 – Kinds of Soil Water
2. Activity Sheet
   - 🖹 AS 1 – Water Retention in Different Soils
3. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
4. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplies & Equipment

- ❑ Three tomato plants
- ❑ Soil samples with different textures from earlier lessons
- ❑ See AS 1 for materials and equipment needed to complete the Activity Sheet.

Supplemental Information

1. Internet Sites
   - ❑ Retention of Water: Basics of Soil-Water Relationships – Part II. Institute of Food and Agricultural Sciences, University of Florida. Accessed May 20, 2008, from http://edis.ifas.ufl.edu/ss109.
   - ❑ Soil Plant Water Relationships. Institute of Food and Agricultural Sciences, University of Florida. Accessed May 20, 2008, from http://edis.ifas.ufl.edu/AE021.
   - ❑ Soil Quality Resource Concerns: Available Water Capacity. USDA Natural Resources Conservation Service. Accessed May 20, 2008, from http://soils.usda.gov/sqi/publications/files/avwater.pdf.
   - ❑ Soils, Water, and Plant Growth. Tree Fruit Soil and Nutrition, Tree Fruit Research and Extension Center, Washington State University. Accessed May 20, 2008, from http://soils.tfrec.wsu.edu/mg/water.htm.
2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.
   - ❑ Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
   - ❑ Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
   - ❑ Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
   - ❑ Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
   - ❑ White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

Select three tomato plants of the same size but grown in different soil textures. Water all the plants the same amount to start the observation. See how long it takes each plant to wilt. After wilt is observed, water the plants and see how quickly they respond to the water. Have students observe how the soil texture affects the water retention of the soil.

Communicate the Learning Objectives

1. Explain the importance of available water to plant growth.
2. Identify the different types of soil waters.
3. Define available water capacity.
4. Explain the effect soil texture has on available water capacity.
5. Explain the effect that effective rooting depth has on available water capacity.
6. Explain the effect rock fragment content has on available water capacity.
7. Identify other factors which affect available water capacity.
8. Explain how available water capacity is determined.
9. Define permeability and identify the soil properties which affect permeability.
10. Identify the factors which affect the internal drainage of soil.
11. Explain how seasonal high water tables are determined.

Instructor Directions	Content Outline
Objective 1 *Discuss the importance of water retention and movement. Use PPt 1 to illustrate water use by plants.* ☐ PPt 1 – Water Removal by Plants	**Explain the importance of available water to plant growth.** 1. All plants need water to survive. Too much or too little can be harmful. 2. Actively growing plants are 90% water. 3. Plants need water to take up nutrients and release moisture through transpiration. 4. Plants use 300-500 lbs of water for every pound of dry weight. 5. Soils with high available water have a greater productivity potential than soils with low available water.
Objective 2 *Discuss what happens in the soil after a heavy rain. Refer to PPt 2.* ☐ PPt 2 – Kinds of Soil Water	**Identify the different types of soil waters.** 1. Gravitational water a. Fills large pores when soil is saturated b. Drains away quickly c. Plants cannot use 2. Capillary water a. This is held in smaller soil pores (capillaries) – Gravity – Cohesion b. Most is available to plants

Instructor Directions	Content Outline
	3. Hygroscopic water a. This is held tightly in tiny soil pores. – Adhesion – Roots cannot remove it b. Clayey soils contain large amounts c. Plants cannot use this unavailable water.
Objective 3 *Discuss field capacity of the soil. Also discuss the difference between available water capacity (AWC) and the wilting point. Refer to PPt 2.* ☐ PPt 2 – Kinds of Soil Water	**Define available water capacity.** 1. The potential of a soil to hold water in a form available to plants; the amount of water held between field capacity and the wilting point. 2. Reservoir of water within the soil which plants can use.
Objective 4 *Use the soil samples with different soil textures from earlier lessons. Have the samples moist and let the students handle the samples. Ask the students to describe the water-holding capacity. Discuss Figure 10.3 in the student reference. Have students complete AS 1.* AS 1 – Water Retention in Different Soils	**Explain the effect soil texture has on available water capacity.** 1. Soil texture has the greatest effect of the soil properties that influence AWC. 2. Water is held on the surfaces of soil particles. 3. Surface areas per volume of soil are dependent on the soil particle size. a. Clay has a large surface area per volume. b. Sand has a small surface area per volume. c. Silt has a medium surface area per volume. 4. Texture of different soil layers influences the downward movement of water. a. Clay can delay downward movement if it is close to the surface. b. Clay in a lower layer can pull water from layers above.
Objective 5 *Discuss the limiting factors in the soil that affect the rooting depth of plants. Have students give ideas on the effects of rooting depth on AWC.*	**Explain the effect that effective rooting depth has on available water capacity.** 1. Density of soil layers that limit rooting depth also limits AWC. a. Fragipans b. Gravelly or cobbly layers c. Bedrock 2. Soils allowing deep rooting are potentially very productive. a. Greater volume of soil for water and nutrients

Instructor Directions	Content Outline
	b. Good drainage and good aeration favor root penetration 3. Soils with restricting rooting depths are more susceptible to drought and have lower available water capacity.
Objective 6 *Discuss the soil in your area. Ask the students to estimate the water storage capacity of soils containing rock fragments.*	**Explain the effect rock fragment content has on available water capacity.** 1. Horizons containing rock fragments contain less AWC. 2. Rock fragments cannot store water.
Objective 7 *Discuss the influence of soil structure and organic matter content on AWC. Ask the students what other factors might affect the available water capacity.*	**Identify other factors which affect available water capacity.** 1. Structure and organic matter a. Influence the size of aggregates b. Affect the amount of pore spaces between particles 2. Structure and density a. Dense layers with poor structure inhibit rooting depth b. Fragipans 3. Abrupt changes in soil texture from one horizon to another
Objective 8 *Discuss what soil properties provide clues for determining available water capacity. Ask students how they would calculate the AWC of a particular soil. Refer to Figure 10.6 of the student reference.*	**Explain how available water capacity is determined.** 1. Multiply AWC rate by horizon thickness by percent fine earth. a. Determine AWC rate for a particular soil texture. b. Measure the thickness of the horizon. c. To find the percentage of fine earth, subtract the percentage of rock fragment from 100%. 2. Repeat calculation for each horizon within the effective rooting depth. 3. Add together the AWCs for all horizons within the effective rooting depth.
Objective 9 *Discuss texture of the soil as it relates to permeability. Discuss Table 10.3 and Table 10.4 of the student reference.*	**Define permeability and identify the soil properties which affect permeability.** 1. Permeability is affected by the rate at which water moves through a saturated soil. Least permeability layer is used.

Instructor Directions	Content Outline
	2. Porosity, size of pores, and interconnection of pores influence permeability. a. Texture b. Structure c. Density d. Organic matter content e. Mineralogy
Objective 10 *Refer to Figure 10.7 of the student reference to discuss classes of internal drainage. Discuss what factors might indicate or affect the internal drainage of soil.*	**Identify the factors which affect the internal drainage of soil.** 1. Height of the water table 2. Length of time that soil remains saturated
Objective 11 *Explain that a seasonal high water table is the highest average depth of a saturated zone during the wettest season. Analyze the water resources in your area. When do you expect seasonal high water in your area?*	**Explain how seasonal high water tables are determined.** 1. By evidence of reduction a. Grayed colors b. Gray mottles 2. By using boreholes to measure depth and duration of water table a. Apparent water table stands in a freshly dug borehole b. Perched water table levels fall when bore is extended
Application AS 1 – Water Retention in Different Soils	Answers to AS 1: 1. The crumbly soil will have more air spaces between the particles. Soils high in humus have high water-holding capacity and act like a sponge. 2. Lack of organic matter 3. Organic matter increases water-holding capacity of the soil and helps prevent soil erosion. Other activities: 1. Grow several pepper plants in pots until each has several leaves. The divide the plants into three groups, watering each differently. Water one group so often that the soil stays wet. Water a second group when the soil surface dries. Water the third group only when the plants wilt. Have the students observe

Instructor Directions	Content Outline
	the difference in plant growth and discuss the importance of water. Have the students explain field capacity and available water. 2. Have ready for class soil samples of texture ranging from sandy to clay. Take three one-gallon cans and cut out both ends and set them on the ground. Fill each can with a different soil sample. Pour a half-gallon of water through each sample and discuss the results.
Closure/Summary	Plants need water to survive, although the amount of water needed varies widely. There are three kinds of soil water: gravitational water, available water, and unavailable water. Available water capacity (AWC), the capacity of soil to hold water in a form available to plants, is largely determined by soil texture. Soil permeability, internal soil drainage, and effective rooting depth (based largely on soil texture and structure) all work together to influence the available water capacity of a particular soil.
Evaluation: Quiz	Answers: 1. b 2. d 3. g 4. i 5. h 6. j 7. c 8. f 9. e 10. a

Course	Agricultural Science II
Unit	Soil Science
Lesson	Site Characteristics
Estimated Time	50 minutes

Student Outcome

Describe the various site characteristics.

Learning Objectives

1. Explain how landform affects land use.
2. List the major landforms.
3. Explain how percent slope is determined.
4. Explain the relationship between percent slope and water erosion.
5. Explain how you identify parent material.
6. Describe the effect of stoniness on land use.
7. List the factors which affect water erosion.

Grade Level Expectations

SC/ES/1/B/09-11/a SC/ES/2/A/09-11/a SC/ES/2/A/09-11/b

SC/ES/3/A/09-11/c

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - ☐ PPt 1 – Reading Slope With an Abney Hand Level or Clinometer
   - ☐ PPt 2 – Judging Soil Slope
   - ☐ PPt 3 – Slope Diagram Showing Feet Fall Per 100-Foot Distance
2. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
3. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplies & Equipment

- ❑ Soil Judging Scorecard (found on DESE's website)
- ❑ Abney level or clinometer

Supplemental Information

1. Internet Sites
   - ❑ Missouri Soil Judging Scorecard. Missouri Department of Elementary and Secondary Education. Accessed May 20, 2008, from http://www.dese.mo.gov/divcareered/AG/CDE/SoilsScorecard.pdf.
   - ❑ Soil Erosion, Crop Productivity, and Cultural Practices. Iowa State University Extension. Accessed May 20, 2008, from http://www.extension.iastate.edu/Publications/PM1870.pdf.

2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.
   - ❑ Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
   - ❑ Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
   - ❑ Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
   - ❑ Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
   - ❑ White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

Discuss site evaluation as it relates to soil judging. Introduce the Soil Judging Scorecard (found on DESE's website) and explain the section on Site Characteristics.

Communicate the Learning Objectives

1. Explain how landform affects land use.
2. List the major landforms.
3. Explain how percent slope is determined.
4. Explain the relationship between percent slope and water erosion.
5. Explain how you identify parent material.
6. Describe the effect of stoniness on land use.
7. List the factors which affect water erosion.

Instructor Directions	Content Outline
Objective 1 *Discuss why site evaluation is just as important in soil judging as a description of each horizon. Take a field trip and evaluate a landform.*	**Explain how landform affects land use.** 1. Site characteristics a. Runoff b. Erodibility c. Internal drainage 2. Management decisions a. Choice of crops b. Tillage systems c. Mechanical practices d. Drainage systems e. Irrigation
Objective 2 *Discuss landforms in your area and procedures for evaluation.*	**List the major landforms.** 1. Uplands 2. Foot slopes 3. Alluvial fans 4. Flood plains 5. Stream terraces 6. Sinkholes
Objective 3 *Discuss the importance of slope and how it affects the use and management of the soil. Demonstrate the use of an Abney level or clinometer to measure slope. Since your students will not have instruments to judge slope,*	**Explain how percent slope is determined.** 1. Place two stakes a certain distance apart (run) on the slope. 2. Calculate the difference in the two elevations (rise). 3. Divide the rise by the run. 4. Change fraction to percentage.

Instructor Directions	Content Outline
estimate the slope gradient within a percent or two. Show PPt 1, PPt 2, and PPt 3. ☐ PPt 1 – Reading Slope With an Abney Hand Level or Clinometer ☐ PPt 2 – Judging Soil Slope ☐ PPt 1 – Slope Diagram Showing Feet Fall Per 100-Foot Distance	
Objective 4 *Discuss with students how a slope's length, shape, and gradient determine erodibility. Also discuss how the aspect of a slope influences moisture and plant growth as it relates to erosion.*	**Explain the relationship between percent slope and water erosion.** 1. The greater the percent slope (gradient), the higher the erosion rate. 2. The steeper the slope, the greater the runoff. 3. As length increases, so does volume and speed of runoff water.
Objective 5 *Discuss parent material and how they are developed.*	**Explain how you identify parent material.** 1. Parent material is determined by comparing upper horizons with C and R horizons. a. C horizons usually represent original parent material. b. Landforms of a soil indicate the kind of parent material. c. Geology of an area provides clues to parent material. d. Abrupt changes may indicate two parent materials. 2. Six types of common parent materials have their own characteristics. a. Residuum: unconsolidated, weathered mineral material b. Alluvium: sand, silt, and clay sediments deposited by flooding c. Loess: clays and silts deposited by wind d. Eolian sand: sand dunes deposited by wind action

Instructor Directions	Content Outline
	e. Glacial till: clay, silt, sand, and gravel transported by glaciation f. Colluvium: loose soil and rocks transported down steep slopes
Objective 6 *Explain that stoniness is defined in terms of its impact on agricultural management. Discuss classes of stoniness. Ask the students how each class of stoniness might affect land use.*	**Describe the effect of stoniness on land use.** 1. Stoniness interferes with tillage 2. Can make cultivated crops impractical – could still work for hay crops or improved pasture 3. Can prevent any agricultural improvements – use as native pasture or range 4. Rockiness also limits cultivation
Objective 7 *Discuss the hazards of soil erosion by water. Talk about damages erosion does to productivity and water quality. Refer to Table 11.2 in the student reference.*	**List the factors which affect water erosion.** 1. Slope a. Steepness of slope b. Length of slope 2. Runoff a. Soil texture b. Permeability and infiltration c. Soil depth d. Vegetative cover e. Climate
Application	Other activities: 1. Tour local farms and observe the six general landforms that are common in the state. 2. Invite your Natural Resources Conservation Service (NRCS) representative to speak to your class. 3. Show a slide set of soil erosion to illustrate types and effects of erosion.
Closure/Summary	Land forms have characteristic shapes and are produced by natural geologic processes. The six general landforms that commonly occur in the state are uplands, foot slopes, alluvial fans, flood plains, stream terraces, and sinkholes. There are five major characteristics used in a site evaluation: landform, slope, aspect, parent material, and stoniness. Both slope steepness and slope shape are important considerations in a site evaluation.
Evaluation: Quiz	Answers: 1. c 2. b

Instructor Directions	Content Outline
	3. d 4. i 5. f 6. g 7. h 8. e 9. j 10. a 11. Rise ÷ Run = % Slope 12. 10% 13. a. Uplands b. Flood plain 14. a. Convex b. Concave c. Linear 15. a. Slope shape b. Slope length c. Slope gradient

Course	Agricultural Science II
Unit	Soil Science
Lesson	Interpretations and Management of Soil
Estimated Time	Two 50-minute blocks

Student Outcome

Identify ways to conserve and manage the soil.

Learning Objectives

1. Explain how site characteristics and soil properties determine the need for artificial drainage.
2. Identify the soil properties which determine the suitability for irrigation.
3. Describe the management practices which are used to control erosion.

Grade Level Expectations

SC/EC/1/C/09-11/a	SC/EC/1/C/09-11/b	SC/EC/1/D/09-11/a
SC/ES/1/B/09-11/a	SC/ES/2/A/09-11/a	SC/ES/2/A/09-11/b
SC/ES/3/A/09-11/c	SC/ES/3/A/09-11/e	SC/ST/1/B/09-11/a
SC/ST/1/C/09-11/a	SC/ST/3/B/09-11/a	SC/ST/3/B/09-11/b
SC/ST/3/B/09-11/c	SC/ST/3/D/09-11/a	

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - ☐ PPt 1 – Types of Terraces
   - ☐ PPt 2 – Cross Section: Steep Backslope Terrace
   - ☐ PPt 3 – Cross Section: Broad-base Terrace
2. Activity Sheet
   - AS 1 – How Cover Crop Affects Soil Loss
2. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
3. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplemental Information

1. Internet Sites
   - ❑ Soil and Water Publications. University of Missouri Extension. Accessed May 20, 2008, from http://extension.missouri.edu/explore/agguides/soils/.
   - ❑ Soil, Water, and Plant Characteristics Important to Irrigation. North Dakota State University Agriculture and University Extension. Accessed May 20, 2008, from http://www.ag.ndsu.edu/pubs/ageng/irrigate/eb66w.htm.

2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.
   - ❑ Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
   - ❑ Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
   - ❑ Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
   - ❑ Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
   - ❑ White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

Invite prominent farmers to visit the class to explain proper management of the soil.

Communicate the Learning Objectives

1. Explain how site characteristics and soil properties determine the need for artificial drainage.
2. Identify the soil properties which determine the suitability for irrigation.
3. Describe the management practices which are used to control erosion.

Instructor Directions	Content Outline
Objective 1 *Discuss the feasibility and cost of artificial drainage in your farming community. Discuss areas where drainage may be prohibited by wetland regulations. Discuss site characteristics and soil properties that indicate the need for surface drainage. Refer to Figure 12.1 in the student reference.*	**Explain how site characteristics and soil properties determine the need for artificial drainage.** 1. Somewhat poorly drained, poorly drained, or very poorly drained soils that are nearly level with depressional spots a. Sites on which surface water stands for continuous periods of 8 hours or more 2. Sloping soils below seepy spots a. Hillsides and foot slopes
Objective 2 *Have members of the class do a survey of the different systems of irrigation used in our community. Discuss cost figures for the systems mentioned. Ask students to name local areas they believe need irrigation. Discuss the suitability of irrigation for those areas. Refer to Table 12.1 in the student reference.*	**Identify the soil properties which determine the suitability for irrigation.** 1. Evaluate these properties as an asset or a liability a. Surface texture b. Slope c. Available water capacity (AWC) d. Depth to high water table e. Permeability f. Percent of rock fragments g. Depth to bedrock
Objective 3 *Discuss the amount of topsoil lost to erosion each year. Discuss erosion control measures such as no-till, terraces, and contour farming. Show students PPt 1, PPt*	**Describe the management practices which are used to control erosion.** 1. Tillage practices a. No-till b. Conservation tillage 2. Cropping Practices a. Contour planting

Instructor Directions	Content Outline
2, and PPt 3. Have students complete AS 1. 🗔 PPt 1 – Types of Terraces 🗔 PPt 2 – Cross Section: Steep Backslope Terrace 🗔 PPt 3 – Cross Section: Broad-base Terrace 🖹 AS 1 – How Cover Crop Affects Soil Loss	b. Contour strip cropping c. Grassed waterways d. Conservation cropping sequence 3. Terraces can be either gradient or parallel a. Broad-base terraces b. Narrow-base terraces c. Steep backslope terraces
Application 🖹 AS 1 – How Cover Crop Affects Soil Loss	Answers to AS 1: 1. Water rushed off the bare soil into the jar, taking soil with it. The jar will contain muddy water. 2. The water that flows from the sod will be reasonably clear. It will take longer for the flow to start and it will continue longer. 3. The experiment proves the importance of a cover crop. Other activities: 1. Conduct field trips to observe irrigation practices. 2. Invite an NRCS or Water Conservation District representative to speak to the class about ways a farmer can solicit assistance in developing a conservation plan. 3. Show videos covering additional types of drainage and conservation. These are available through the Department of Conservation.
Closure/Summary	The first steps in evaluating soils involve learning how to identify horizons and site characteristics. The next steps examine the use and management of the soil. Management practices include the suitability of artificial drainage and irrigation, water erosion, evaluating the erosion hazard, conservation practices for erosion control, and hazards or limitations for cropping systems.

Instructor Directions	Content Outline
Evaluation: Quiz	Answers: 1. a. How to identify horizons and site characteristics b. Examine the use and management of the soil 2. a. Texture b. Slope 3. a. Broad-base b. Narrow base c. Steep backslope 4. No-till 5. Contour strip cropping

Course	Agricultural Science II
Unit	Soil Science
Lesson	Environmental Impact of Soil and Water Management
Estimated Time	50 minutes

Student Outcome

Describe the environmental impact of soil and water management.

Learning Objectives

1. Identify the soil properties which affect leaching of pesticides and fertilizers.
2. Identify the soil properties which affect water runoff.
3. Identify the soil properties which affect site selection of water holding structures.
4. Identify the soil properties that are important for determining building sites.
5. Identify the soil properties that are important for on-site waste disposal.

Grade Level Expectations

SC/EC/1/C/09-11/a	SC/EC/1/C/09-11/b	SC/EC/1/D/09-11/a
SC/ES/1/B/09-11/a	SC/ES/2/A/09-11/a	SC/ES/2/A/09-11/b
SC/ES/3/A/09-11/c	SC/ES/3/A/09-11/e	SC/ES/3/A/09-11/g
SC/ST/1/B/09-11/a	SC/ST/1/C/09-11/a	SC/ST/3/B/09-11/a
SC/ST/3/B/09-11/b	SC/ST/3/B/09-11/c	SC/ST/3/D/09-11/a

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.
2. *Soil Science Curriculum Enhancement.* University of Missouri-Columbia: Instructional Materials Laboratory, 2003.

Supplemental Information

1. Internet Sites
   - ❑ Huddleston, J. H. *How Soil Properties Affect Groundwater Vulnerability to Pesticide Contamination.* Oregon State University Extension Service. Accessed May 21, 2008, from http://www.pw.ucr.edu/textfiles/Soil%20Properties%20and%20Groundwater%20Contamination.pdf.
   - ❑ Soil and Water Publications. University of Missouri Extension. Accessed May 21, 2008, from http://extension.missouri.edu/explore/agguides/soils/.
   - ❑ Soil Facts: Soils and Water Quality – How Soils Influence Water Quality. North Carolina State University Cooperative Extension Service. Accessed May 21, 2008, from http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-01/.
2. Print
   - ❑ Ashman, Mark R., and Geeta Puri. *Essential Soil Science: A Clear and Concise Introduction to Soil Science.* Malden, MA: Blackwell Publishing, 2002.

- Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils.* 14th ed. Upper Saddle River, NJ: Prentice Hall, Inc., 2007.
- Coyne, Mark S., and James A. Thompson. *Fundamental Soil Science.* Clifton Park, NY: Delmar CENGAGE Learning, 2005.
- Donahue, Roy L., and Roy Hunter Follett. *Our Soils and Their Management*. Danville, IL: Interstate Publishers, Inc. 1990.
- Plaster, J. Edward. *Soil Science and Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
- White, Robert E. *Principles and Practice of Soil Science: The Soil as a Natural Resource.* 4th ed. Malden, MA: Blackwell Publishing, 2005.

Interest Approach

Discuss soil in your area. Ask the students to evaluate the environmental impact on soils as it relates to water management.

Communicate the Learning Objectives

1. Identify the soil properties which affect leaching of pesticides and fertilizers.
2. Identify the soil properties which affect water runoff.
3. Identify the soil properties which affect site selection of water holding structures.
4. Identify the soil properties that are important for determining building sites.
5. Identify the soil properties that are important for on-site waste disposal.

Instructor Directions	Content Outline
Objective 1 *Discuss the effects of pesticide leaching onto your garden or crop.*	**Identify the soil properties which affect leaching of pesticides and fertilizers.** 1. Surface infiltration a. Texture b. Permeability c. Restrictive layers d. Shrink-swell potential 2. Permeability a. Soil structure b. Particle size distribution c. Bulk density d. Restrictive layers
Objective 2 *Discuss how pesticides and fertilizers are carried off by water runoff. Discuss the importance of water quality and its effect on your health. Also discuss how reducing leaching and water runoff losses would improve the overall water quality.*	**Identify the soil properties which affect water runoff.** 1. Rate of runoff a. Slope b. Texture (surface layer) c. Permeability d. Restrictive layers e. Soil depth f. Shrink-swell potential g. Internal drainage 2. Erodibility a. Particle size distribution b. Soil structure c. Permeability

Instructor Directions	Content Outline
Objective 3 *Discuss the guidelines in selecting a site to construct a pond. Refer to Table 13.1 in the student reference.*	**Identify the soil properties which affect site selection of water holding structures.** 1. Low seepage potential in upper 60 inches a. Permeability b. Depth of bedrock c. Depth of highly permeable material 3. Percent slope
Objective 4 *Discuss the soil features that will determine construction of dwellings with a basement. Refer to Table 13.2 and Table 13.3 in the student reference.*	**Identify the soil properties that are important for determining building sites.** 1. Depth to high water table 2. Flooding 3. Shrink-swell potential 4. Slope 5. Depth to bedrock 6. Rock fragments
Objective 5 *Discuss regulations concerning the construction of a water disposal system. Ask the students what soil characteristics they would look for. Also mention any approval required by governing agencies. Refer to Figures 13.1 and 13.2 as well as Tables 13.4 and 13.5 in the student reference.*	**Identify the soil properties that are important for on-site waste disposal.** 1. Soil properties that affect absorption fields a. Permeability b. Depth to seasonal high water table c. Depth to bedrock or restrictive layer d. Slope e. Flooding f. Rock fragments greater than 3 inches to a depth of 40 inches 2. Soil properties that affect sewage lagoons a. Permeability b. Slope c. Flooding d. Seasonal high water table or internal drainage e. Depth to bedrock f. Rock fragments (percentage of cobbles and stones)
Application	Other activities: Have a local planning and zoning official or health inspector speak to the class on soil and site characteristics they have encountered.

Instructor Directions	Content Outline
Closure/Summary	Pesticides and fertilizers can be lost from the soil by leaching and water runoff and can pollute underground and surface water supplies. Soil properties can be evaluated to determine the potential to transmit water-soluble contaminants and to determine potential water runoff. The soil properties that affect permeability and erodibility impact the environment and need to be evaluated when determining land usage.
Evaluation: Quiz	Answers: 1. a. High water table b. Flooding c. Shrink-swell potential d. Slope e. Depth of bedrock 2. a. Permeability b. Seasonal high water table c. Shallow soil d. Slope e. Flood plains or rock fragments 3. a. Soil texture b. Permeability c. Restrictive layers d. Soil depth e. Shrink-swell potential 4. a. Leaching b. Water runoff