Acknowledgements

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About

This kit contains a series of hands-on activities and lessons with the objective of teaching middle and high school youth several concepts in science and systems thinking that are foundational to the management of sustainable agricultural systems.

Topics covered in this kit include:

- Crop planning
- Pest management
- Phenology
- Record keeping and making observations
- Soil, formation, structure and ecology

As anyone who's ever gardened or farmed in Minnesota may know, our growing season can be unpredictable, bipolar, and brief. Be mindful of the biophysical materials you'll need to complete each lesson. Four out of five of the lessons include considerations, suggestions, and materials for conducting the lesson both in-person and in distance learning.

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Land-Use & Planning Your Agroecosystem

Summary

Students grade environments in terms of their ability to support agricultural production and design a simple plant system and planting/harvesting schedule for a single season of operation.

By the end of this lesson, students will be able to:

- ...define an agroecosystem.
- ...identify fundamental components of an agroecosystem- be that biotic or abiotic, man-made or natural.
- ...design a simple plant system and planting/harvesting schedule.
- ...defend their land-use and management decisions.

Materials

- 5-7 locations the students can learn more about online
- Printed *Getting To Know Your Farm* Handouts
- Printed *Crop Planning* handout
- Computers or smartphones and access to the internet.

Lesson Overview

>> *Introduction* *(15 min.)*

What is an agroecosystem?

What is infrastructure and what kinds of infrastructure are necessary for agriculture?

>> *Activity* *(15 min.)*

Grade and order the various sites in terms of their ability to support an economically viable agricultural production.

Design a simple plant system and planting/harvest schedule.

>> *Wrap-Up* *(15 min.)*

Agroecosystem, land-use, and system design discussion

Background

An **agroecosystem** is composed of an assortment of biotic and abiotic, natural and man-made, and physical and socioeconomic parts that are necessary to maintain an agricultural operation. Any economically viable agricultural operation requires space, inputs for animal and/or plant production (including nutrition, water, and health), access to markets, and, depending on the agricultural product, access to certain infrastructure for post-harvest processing and handling.

Can you make any space a thriving, viable agroecosystem? That's the question we're posing today. While analyzing potential agroecosystems, ask yourself how the climate will impact your operation and if you'll have access to the necessary inputs, infrastructure, and markets to develop a viable agricultural operation.

Markets can include farmer's markets, grocery stores, restaurants, schools and hospitals, and so much more. Can you think of any more? Infrastructure might include roads, mechanical equipment like tractors, infrastructure for accessing water. Can you think of anything else that could fall into the infrastructure category? Inputs might will include things like seeds, fertilizer, water, and if you're interested in animal production you'll require animal feed and veterinary services. Can you think of any other inputs an agricultural operation might require?

Set-Up

1. Identify 5-7 locations within your region that the students can explore online via Google Maps and the U.S. Soil Survey. In addition to location, identify how large each location will be, defined in acres.
2. Assign each group of students 3-4 locations and have a means of disseminating the location assigments to each group of students.

Introduction (10 min.)

1. Explain that viable agricultural operations are made up of many different types of parts: man-made and natural, abiotic and biotic, biological and social, etc. Give a few examples of each.
2. Write the words "Climate and Ecology", "Infrastructure", "Markets", and "Inputs" on the board. Explain what each word means and ask the students to give examples that could go under each category.

Activity (30 min.)

1. Distribute the 3-4 regional locations to each group of 3-4 students.
2. Introduce the students to the first portion of the activity: the students will use the information they just learned out about ecosystems and inputs for agricultural production to grade the 3-4 different sites they've been assigned according to their ability to support agricultural production. Students will need to defend their "best" and "worst" grades. As there's as many locations as there are students in a group, each should take a location and research it online using Google Maps, the U.S. Soil Survey website, and other online resources and report it's pros and cons back to the group.
3. Give the students 15 minutes to explore their assigned locations online and prepare a defense for their "best" and "worst."
4. After 15 minutes, ask each group to present their "best" and "worst". Respond appropriately to each group's defense.

5. Once every group has presented, introduce them to the second portion of the activity: the students will use either their "best" or "worst" environments to design a simple plant system and a planting/harvesting schedule for a single season of operation. Remind students that the length of their season may differ from what they're used to and they might want to look it up.
6. Give students 15 minutes to complete this portion of the activity.

Wrap-Up (10 min.)

1. After 15 minutes, bring the groups back together.
2. Have each group present their business plan, simple plant system, and planting/harvesting schedule.
3. After each group has presented, begin a discussion about what influenced their decisions.
    a. Why did they choose the plants they did for their systems? Economics, food preferences, the environment, etc.?
    b. Did any groups try to design a system for their "worst"? If so, why?

Getting to Know Your Farm

As the owners and managers of a new agricultural operation, it's up to you to 1) name and develop a 1-page business plan for your farm (the markets you'll cater to (CSA, wholesale, farmers markets, restaurants, etc.), the agricultural products you'll produce (annual vegetables, stone fruit, berries, gourds, meat, dairy products, etc.), mission statement and 2) break that business plan down into a coherent planting/harvesting schedule.

Farm name

____

What is the mission of your group's farm?

____

____

What markets does your farm hope to sell to? How many times in a growing season does your farm have to harvest and prepare produce for market?

____

____

____

____

Getting to Know Your Farm

How long is your growing season?

What high and low temperatures are recorded in the area of your farm during the growing season?

What is the first day of planting in the area of your farm? And when is the typical first frost date in the area of your farm?

How many garden beds or plots can you prepare within the space that makes up your farm? How big are they- in square feet?

Crop Planning

In this graph, identify the varieties of crops you'll plant, their days to maturity, harvest and plant dates, and any notes your group wants to add. While working on this sheet, consider the following: how do I get the most

Crop Variety	Harvest Date	Days to Maturity	Field Date	Harvest Need	Notes

Crop Planning

In this graph, identify the varieties of crops you'll plant, their days to maturity, harvest and plant dates, and any notes your group wants to add. While working on this sheet, consider the following: how do I get the most

Crop Variety	This is the variety of crop you're planting and harvesting. It may impact how large your plant grows and/or how long it takes the crop to mature.
Harvest Date	This is the date you want to harvest your crop by. You'll want to harvest your crops 1-3 days before you intend to offer them at market.
Days to Maturity	This is the number of days it will take your crop to mature. You can typically find it on the packaging of your seeds or online.
Field Date	This is the date you need to get your plants into the ground by. **Field Date= Harvest Date - DTM**.
Harvest Need	This is how much of a crop variety you need to have harvested to sell to your market.
Yield (per sq. ft.)	This is how many plants you can plant and harvest within the space you have. When deciding how many plants you can fit into the space you have, consider how much room in square-feet each plant will need to mature.

Soil Texture Evaluation: Lab vs. Field

Summary

Students learn about soil formation and soil texture before trying their hand at determining soil texture by feel, a method used by soil scientists in the field.

By the end of this lesson, students will be able to:

- ...define soil texture.
- ... describe the differences between determining soil texture in the field vs. a laboratory.
- ...explain why soil texture is a critical property for soil management.

Materials

- Soil Texture Triangle
- Guide to Texture by Feel graphic
- A saucer or bottle of water for each group
- Soil Samples- with known texture
- Slides for Determining Soil Texture in the Lab

Lesson Overview

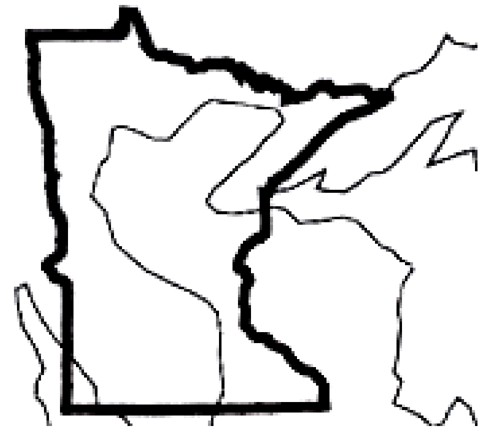
>> *Introduction* *(15 min.)*
General soil formation in MN
What is soil texture?

>> *Activity* *(15 min.)*
Determining soil texture by feel

>> *Wrap-Up* *(15 min.)*
Soil texture discussion

The Remote version of this lesson cannot be completed in the winter, the soil needs to be thawed and permeable.

Background



Soil texture is one of the first soil properties determined by scientists, agriculturalists, and other land and water managers gathering information about an area. Of the 4 components that make up soil (mineral material, organic matter, water, and air), a soil's mineral factor is the largest- 45% by volume on average. Soil texture refers to the consistency a soil owes to the relative amounts of sand, silt, and clay present in that soil. The differences between these minerals- in their sizes, chemical composition, and chemical charge- influences the condition of several physical and chemical properties of soil, and so ultimately influences how the soil behaves.

Beginning about 10,000 years ago, during the Wisconsin glacial period of the last ice age, the thawing, freezing, movement, and deposition from glacial lobes derived from the **Laurentide Ice Sheet** (LIS) determined the mineral **parent material** from which the majority of MN soils were formed. The eastern half of the state was formed from iron-rich igneous rock, the **Superior lobe** of the LIS, producing a sandy soil with a low pH. The western half of the state was formed from the calcium-carbonate-rich **Des Moines lobe**, producing a soil with more silt and clay and a high pH.

The **Natural Resource Conservation Services (NRCS)**, an agency within the **United States Agricultural Department (USDA)**, performs extensive surveys of the nation's soils, called the **National Cooperative Soil Survey**. The various soil properties and results of that survey, including the condition of soil pH, texture, organic matter, and other important soil properties, have been digitized and made available to the public via the **Web Soil Survey (WSS)**. Visit https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm to review the site.

Materials

- Soil Texture Triangle
- Guide to Texture by Feel graphic
- A saucer or bottle of water for each group
- Soil Samples with known texture
- Slides for Determining Soil Texture in the Lab

Set-Up

In-person

1. Print and have copies of the Guide to Texture by Feel and the Soil Texture Triangle available for students to refer to. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054311
2. Collect samples for various soil textures; have samples tested if soil texture is unknown. Record where each sample was taken from.

Remote

1. Have PDFs or images of the Guide to Texture by Feel and the Soil Texture Triangle available for students to refer to.
2. You and students will be collecting soil samples for this activity from outside of their own abodes. Collect yours before the class begins.

Introduction (10 min.)

1. Draw on the board or otherwise project the state of MN and the southern perimeter of the Laurentide Ice Sheet that ran through the state. See an example of this under the **Background** section for this lesson.

   Ask students if they can identify what the LIS line is supposed to represent; wait an appropriate amount of time for responses and respond accordingly.

2. Tell the story of the Laurentide Ice Sheet and the Superior and Des Moines lobes that moved through MN- the freezing, thawing, movement, and outwash from which, is responsible for much of the mineral parent material and topography observed in modern MN soils and landscapes.
   a. Define **parent material** for those who may not be familiar with the term.
3. Briefly explain what soil texture is and that it depends on the relative amounts of sand, silt, and clay found in the soil.

Activity (15 min.)

In-person

1. Handout materials for the activity- the Soil Texture by Feel graphic, soil texture triangle, the 3 samples, and water.
2. Introduce students to the activity they'll be completing today: There are a few different ways to determine soil texture. In the field, many ag. professionals determine soil texture by feel.
3. Demonstrate to the class how to use the graphic using a sample that isn't one of the three they have.
4. Have students record in their notebooks the soil textures of the three samples.
5. Give students approximately 10 minutes to work on determining the texture of their soil samples.

Remote

1. Introduce students to the activity they'll be completing today: There are a few different ways to determine soil texture. Similar to many ag. and soil scientists in the field, we will be collecting soil samples and determining soil texture by feel.
2. Using the soil you've already collected, demonstrate to the class how to use the soil texture by feel graphic.
3. Instruct students to quickly collect their own samples from outside, about 3/4 of a cup, and try their hand at determining the texture of their own samples. Give students about 15 minutes to complete this portion of the activity.
4. Have students record the soil texture they've determined in their notebooks.

Wrap-Up (15 min.)

In-person

1. After 10 minutes, gather the groups back together and begin a 10-minute discussion about the activity and the implications of soil texture on an agricultural operation.
   a. What soil textures did students determine for their samples?
   b. How might soil texture impact or constrain an agricultural operation?
      i. Impacts soil drainage, soil pH, bulk density, the type of vegetation that will grow within that parent material and weather the parent material.
2. Pull up and display the homepage of the Web Soil Survey, by the Natural Resources Conservation Services of the USDA: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

3. Take a moment to briefly introduce your students to the site (what it is, who manages it, some of it's uses in agriculture and construction.)
4. Press the "START WSS" button. Search for one of the locations you took a soil sample from on the soil survey and select your area of interest or AOI.
5. Navigate to the "Soil Data Explorer" tab, then the "Soil Properties and Qualities" tab, then the "Soil Physical Properties" tab. Point out the "Percent Clay", "Percent Silt", and "Percent Sand" categories under "Soil Physical Properties".
6. Have the students take down the % clay, % silt, and % sand and have them check if the textures they wrote down match what the soil survey says.
7. Give the students the last 2 locations for the soil samples and invite them to go onto the site at home and check their work on the last 2 soil samples.
8. Have students reflect on the experience and write about it in 2-3 paragraphs, using some of the vocabulary introduced during this activity.

Remote

1. After 10 minutes, gather the students back together and begin a 10-minute discussion about the activity and the implications of soil texture on an agricultural operation.
    a. What soil textures did students determine for their samples?
    b. How might soil texture impact or constrain an agricultural operation?

i. Impacts soil drainage, soil pH, bulk density, the type of vegetation that will grow within that parent material and weather the parent material.

2. Pull up and display the homepage of the Web Soil Survey, by the Natural Resources Conservation Services of the USDA: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
3. Take a moment to briefly introduce your students to the site (what it is, who manages it, some of it's uses in agriculture and construction.)
4. Show the students your soil sample. Have them guess what it's soil texture might be and write their guesses down.
5. Press the "START WSS" button. Search for the location you took your soil sample from on the soil survey and select your area of interest or AOI.
6. Navigate to the "Soil Data Explorer" tab, then the "Soil Properties and Qualities" tab, then the "Soil Physical Properties" tab. Point out the "Percent Clay", "Percent Silt", and "Percent Sand" categories under "Soil Physical Properties".
7. Have the students take down the % clay, % silt, and % sand and have them check if the textures they wrote down match what the soil survey says.
8. Invite the students to look up their locations on the site at home and check their work on their own soil samples
9. Have students reflect on the experience and write about it in 2-3 paragraphs, using some of the vocabulary introduced during this activity.

Additional Resources:

- **NRCS, Guide to Texture by Feel-** https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054311
- **UMN, MN Glacial Geology-** https://cse.umn.edu/mgs/glacial-geology
- **Oregon State University Extension, SOM-** https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/em9251.pdf
- http://www.thudscave.com/petroglyphs/pdf/mn_parentsoil.pdf
- **UMN Extension, Soil Organic Matter and Glacial Activity-** https://extension.umn.edu/soil-management-and-health/soil-organic-matter-cropping-syste
- **USDA NRCS, Web Soil Survey-** https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

Integrated Pest Management & Crop Scouting

Summary

Students learn about IPM and techniques for crop scouting before practicing them in their agroecosystem.

By the end of this lesson, students will be able to:

- ...define integrated pest management.
- ...describe the approach taken to the design and management of an IPM system.
- ...collect data on local insect populations.
- ...exemplify critical thinking about a particular insect's role in a system.

Materials

- 5-10 disposable cups
- 5-10 numbered flags
- A trowel
- Construction Paper for each group
- Pest ID Handout
- Local and digital IPM resources available for student use
- Crop Scouting Worksheet

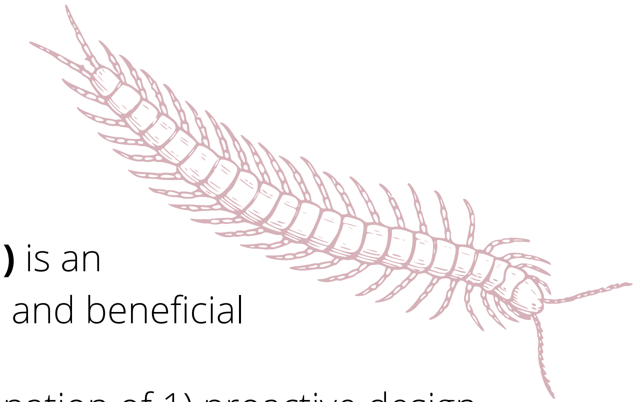
Lesson Overview

>> *Introduction* *(10 min.)*
What is IPM & Crop Scouting

>> *Activity* *(15 min.)*
Crop scouting & using guides to identify pests

>> *Wrap-Up* *(15 min.)*
Post-activity discussion on activity and written reflection on of IPM & Crop Scouting.

Background



Integrated pest management (IPM) is an ecological approach to managing the pests and beneficial organisms present in an agroecosystem.
This approach is achieved through a combination of 1) proactive design and management practices that encourage the availability of habitat for beneficial organisms and increase pressures on pests; 2) monitoring and identifying beneficial organisms and pests, including their relative amounts; and 3) a graduated response structure when damage done by pests surpasses that system's economic injury level.

Collecting information on what insects are present in your farm ecosystem is very important! In an IPM system, farmers use a process called crop scouting to collect information about their agroecosystems. It tells you what types of pests you have to control, what beneficial species call your farm home, how many of each there are, and the condition of your plants and fields. Farmers collect pest information in a variety of ways. These pit traps are one way, sticky traps (like flypaper) are another common method. You can also frequently walk your farm, and see what populations you notice and where. The Pest ID Handout has much of the background info for this demo, make sure you have it handy while presenting.

Procedure

Materials

- 5-10 disposable cups
- 5-10 numbered flags
- A trowel
- Construction Paper for each group
- Pest Handout
- Local and digital IPM resources available for student use
- Crop Scouting Worksheet

Set-Up

In-person

1. Familiarize yourself with the Pest ID Handout, which contains pictures, names and functions of many common farm pests and insects, as well as other physical and digital resources for garden, lawn, and farm pests in your local area.
2. At least an hour before the lesson, set up 4-6 cup/pit traps by digging a hole large enough for the disposable cup, placing it in the ground so the top is level with ground level and filling in around it. This is demonstrated in the image above.
    a. For best results, place in areas with differing vegetation. I.e. grasses, trees, bushes, managed garden beds, etc.
    b. Flag these cups, so you can easily find them again.

Remote

1. Make the Pest Handout and other digital resources for garden, lawn, and farm pests in your local area available for students to refer to.
2. Inform students before this lesson that at least an hour before they're going to complete this activity, they need to set up 4-6 cup/pit traps by digging a hole large enough for the disposable cup, placing it in the ground so the top is level with ground level and filling in around it. Make the example image and tips available to them.

Introduction (10 min.)

1. Introduce students to the concept of integrated pest management
   a. What it is, the importance of a manager's knowledge of their ecosystem, proactive design and management, graduated response system, economic injury levels, and crop scouting.
2. Ask students why some agriculturalists and environmentalists believe IPM and similar ecological approaches are necessary for pest management.
   a. Give students an appropriate amount of time to answer. Their answers/your explanation should include something about IPM being developed in response to overuse of pesticides and herbicides, the creation of superbugs/superweeds, and the negative impacts their use has on many non-target organisms.

Activity (30 min.)

1. Break students up into groups of 3-4 and pass out materials (crop scouting worksheet, white construction paper, and sample collection materials (if you're using them).
2. Introduce students to the crop scouting techniques they'll be using for the activity: *visual observation, shaking plants over sheets (white construction paper) or buckets, collecting soil samples for subterranean insects, and pitfall traps.*
3. Explain that while they scout their crops they'll fill out the Crop Scouting Worksheet to record the various insect organisms they observe and information about them.
    a. As you know your students best, do they need to be reminded to not be cruel or destructive over the course of the activity?
4. Explain that students should access the local and digital resources for IPM for more information about the insects. You'll be available to answer questions and assist students with the various resources for identifying unfamiliar insects they find.
5. While you have the students together, give them some things to keep in mind when they crop scout and investigate the cups.
    a. Do they notice any patterns in the bug types? Are there any familiar bugs? What else do they notice? Give students 25 minutes to work on this portion of the activity.

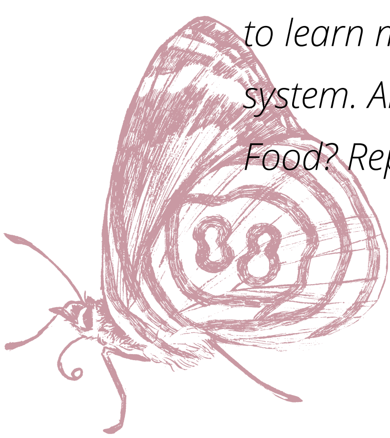
Wrap-Up (15 min.)

1. After 25 minutes, gather the groups back together and begin a 10 minute discussion on what students found, how, and it's importance to the system.

Possible Questions

   a. Are there parts of your system that might be more prone to hosting pests? Standing water? Decomposing materials?
   b. What insects did students identify as pests? Beneficial? Both?
   c. What did students notice?
   d. Were there any similarities among insects observed?
   e. This is one way real farmers collect information on pests, by going out and looking and seeing what's there. Can they think of any other ways to collect pest information?

2. Briefly introduce students to some of the proactive design and graduated responses used to combat economically destructive pests. (Design/Cultural: Intercropping, trap cropping, crop rotations, instrument sanitation; Mechanical: turning over the soil bed between seasons; Applied Biological: animals or insects to eat the pest in question; Chemical: small amounts of specific herbicides and pesticides)
3. Reiterate the importance of farmer/manager familiarity with their ecosystem.
4. *Optional: Invite students to go home and use some of the digital resources to learn more about a pest and techniques used to manage it in an IPM system. Are there techniques that target a susceptible period of its lifecycle? Food? Reproduction?*



Additional Resources:

- **Introduction to Crop Scouting, University of Missouri Extension**- https://extension.missouri.edu/media/wysiwyg/Extensiondata/Pub/pdf/agguides/pests/ipm1006.pdf

Crop Scouting

You will be taking an inventory of the insects present in an agroecosystem using a variety of crop scouting techniques. In the table below, identify the organisms you find, how many, where you found them, and what technique you were using. In the last column, record information about their life cycle, habitat, or feeding that contribute to their survival in your agroecosystem. Include information you already know and new information you learned from one of the resources.

Organism	Number Spotted	Scouting Technique & Location	Strengths, Weaknesses, other notes

Playing with Dirt: Soil Structure & Vegetation

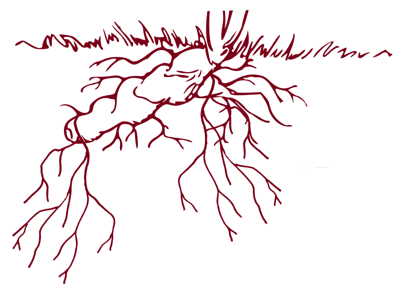
Summary

Students participate in hands-on activities to learn about soil structure and the role of biota and management practices in maintaining that structure and soil health.

By the end of this lesson, students will be able to:

- ...define soil structure.
- ...identify non- nutrient factors of soil health.
- ...exhibit critical thinking about soil management.

Lesson Overview



>> *Introduction* *(15 min.)*

How is soil formed and what is soil structure?
Dissecting soil aggregates warm-up.

>> *Activity* *(25 min.)*

Soil erosion
Tillage and management spectrums
Slake test & Groundcover demo

>> *Wrap-Up* *(10 min.)*

Post-activity discussion on activity and written reflection about soil structure, vegetation, and management practices.

Background

Soil Structure is essentially about formation and interaction of **soil aggregates**, or lack thereof. It may be useful to compare soil aggregates to puzzle pieces, where in a healthy soil they all have their own shape and fit together based on how they interact. Soils that have poor structure are characterized by low numbers of aggregates--it's much harder to put your puzzle together when all of your puzzle pieces have been cut up! If they don't have the right shapes to interlock, what's going to happen to your puzzle? Well, it won't be very strong and is probably going to fall apart.

SAMPLE X is from a field that is regularly mechanically cultivated, and that cultivation breaks up important soil structure and aggregation. SAMPLE Y is from an undisturbed area, where such cultivation happens less frequently and intensively, so that we can do our best to keep the soil in good condition.

What actions can destroy soil structure? **Compaction** (from walking, machinery, etc) of the soil squishes your puzzle pieces, preventing them from fitting together the way they're supposed to and making plant root growth more difficult. **Tillage** breaks your puzzle pieces by intensively mixing up the soil, and many methods of tillage can cause compaction as well.

Erosion is when forces (in nature, usually wind or water) move or break down rocks and soil. Why is soil erosion a problem? It takes the top layer of soil, which farmers often put a high amount of work into. An extreme example of topsoil loss can be found in the Dust Bowl of the 1930's, which was caused in part by poor soil management and led to difficult growing conditions, among other problems. It can also eat away at the landscape in the form of gullies, which can grow into big problems if not taken care of. The Grand Canyon is an example of erosion! Another thing to consider is where that eroded soil goes, and who might have to deal with it.

Groundcover helps keep soil together in a few different ways. Any groundcover on top of the soil will shield the soil surface from direct impacts of rain or wind action, which reduces the overall stress on the soil. In the case of living cover, the plant roots act like lots of tiny arms that are all holding the soil together and supporting it.

Procedure

Materials

Soil Aggregate Disection

- Enough soil aggregates for each student- on paper plates
- Misc. tweezers, spatulas, and delicate hand-tools
- Low quality magnifying glasses
- Dissecting Soil Aggregates Worksheet

Slake Test

- 2 transparent cups, jars, or bottles
- 2 metal cages/baskets- for every group
- Water, or access to a tap- for every group
- 2 soil samples; one from a heavily tilled field with poor soil structure and one from an undisturbed area, with good soil structure- for every group
- Stopwatches or smartphones with timers

Groundcover and Erosion Activity

- 3 2-liter bottles halved the long way.
  - One should be filled with planted vegetation in soil, one with litter-covered soil, and one with bare soil
- 3 water collection containers- for every group
- A gallon of water, or access to a tap

Set-Up

1. Collect soil aggregates from under vegetation for the aggregate dissection warm-up.
2. Collect soil aggregates for the slake test.
   a. Collect 1 of each type of soil aggregate, from tilled and untilled fields or contrasting agroecosystems, such as a cornfield and a garden, for every 3-4 students.
3. Collect bare soil, leaf litter, and planted vegetation for the groundcover demonstration.
4. Print the Dissecting Soil Aggregates worksheet.
5. Prepare enough of the 2-liter bottles for the groundcover demonstration and the slake test. (2 for the slake test for every group; 3 for the groundcover demonstration for each group.)
   a. *Consider having students dissemble 2-liter bottles themselves.*
6. Have materials for hands-on demonstrations readily available or already distributed prior to the activity, including the water.

Introduction (15 min.)

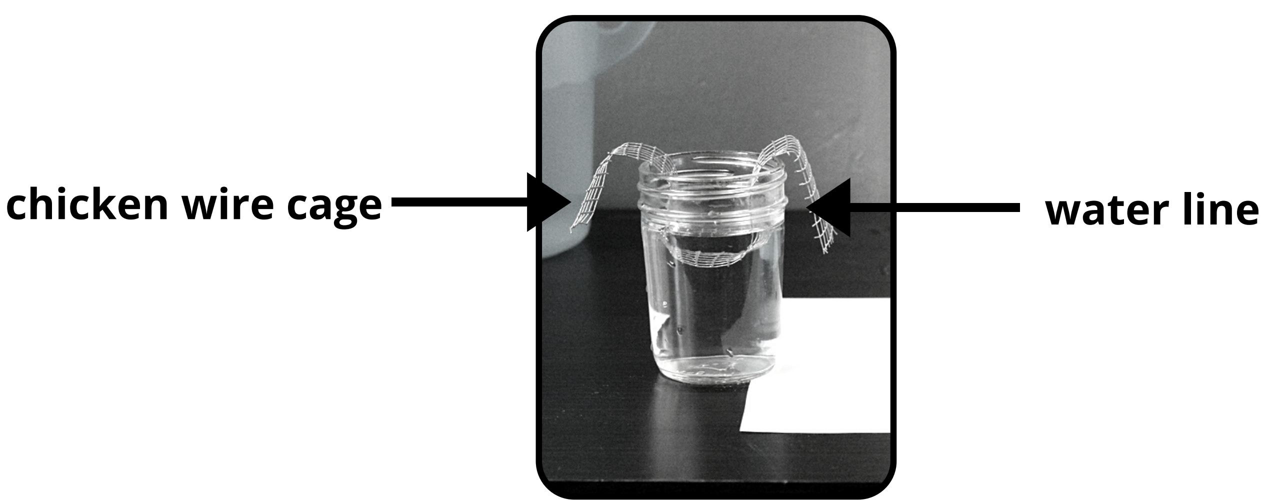
1. Introduce students to the concept of soils as living, complex ecosystems in and of themselves, whose character and structure has been in the process of developing for thousands to millions of years.
2. Introduce students to the warm-up activity: They will be using the misc. tools and magnifying glasses available to dissect their soil aggregates, and will record their observations. Students should draw complexes of soil components through the vantage of their magnifying glasses.

3. Give students about 10 minutes to complete this portion of the activity.
4. After 10 minutes, ask students to share what they found in their aggregates. Did anyone find anything that surprised them?

Activity (25 min.)

Slake Test

1. Briefly introduce students to tillage, the spectrum it exists on, and it's relationship to erosion and soil structure.
2. Show the students both samples for the slake test and explain where each came from. Highlight the important differences in management practices of each sample source.
3. Have the students set up for the slake tests at their tables.
   a. Student Activity Instructions:
      i. Fold the chicken wire into mesh/wire cages and place one in each cup.
      ii. Pour enough water into each cup so the cages are partially submerged. See picture.



4. Before inviting the students to place their samples in the cages, ask what they expect will happen, based on what they've heard about soil structure?
5. Remind students that they will be taking notes on what they observe as the demo proceeds.
6. Instruct the students to begin by gently placing the samples in their cages and beginning their stopwatches/timers.
   a. Some reactions will begin to happen shortly but it will take a few minutes for a dramatic effect to have taken place. During this time, introduce the students to erosion and its consequences. Give students about 7 minutes to time the reaction and take notes.
7. After 7 minutes for the slake test, bring the groups back together for a quick discussion on what students observed and why that might be.

Soil Vegetation Demonstration

1. Briefly introduce students to the concept of soil coverage, and the role of vegetation in soil coverage and erosion prevention.
2. Have students set up for the groundcover demonstration:
    a. Cut in half 3 2-liter bottles
    b. Fill one with the soil under vegetation, one with just soil, and one with soil and leaf litter.
    c. Place the collection containers on the opening of each 2-liter bottle.
    d. See the example picture below.

3. Before inviting the students to begin, ask what they expect will happen, based on what they've learned about vegetation and soil erosion?
4. Remind students that they will be taking notes on what they observe as the demo proceeds.
5. For each 2-liter bottle, students should pour out a few cups of water and take notes on what they observe. Give the students 10 minutes to complete this portion of the activity.

6. After 10 minutes, bring the groups back together for a discussion on what they observed.
    a. Ask students why they think these samples behaved differently.
    b. Make sure two important ideas get covered: in the litter and living covers, the ground has something to directly protect it. And, in the living cover, the ground has roots to hold it together.

Wrap-Up (15 min.)

1. Ask the students to reflect on and write about the activities and demonstrations they participated in today.
    a. What did they learn from these demonstrations about soil structure, vegetation, and erosion?
    b. In what ways might the principles they learned transfer to larger fields during a heavy rain or in the spring?
    c. How might these principles transfer to making management decisions?

Dissecting Soil Aggregates

You will use the misc. tools at your desk and a magnifying glass to "dissect" your soil aggregate. Record what you observe in the form of a drawing, from the vantage of your magnifying glass, and a few sentences about what physical materials are present, how they interact, and other observations.

(Agro) Phenology

Summary

Students learn about phenology, and how it relates to agriculture amid a changing climate, before beginning their very own phenology journals.

By the end of this lesson, students will be able to:

- ...define phenology, citizen science, and climate change, and describe how they're interrelated.
- ...identify a few historic and current applications of phenological data.
- ...make and record simple phenological observations in their community and agroecosystem.

Materials

- Student agrophenology journals
- Writing, drawing, coloring utensils
- Student phones or cameras- Optional
- Tape, staples, ziplock baggies, etc.- Optional

Lesson Overview

>> *Introduction* *(15 min.)*
- What is (agro) phenology?
- Historic and contemporary applications of phenological data
- Nature's Notebook!
- Making phenology observations.

>> *Activity* *(20 min.)*
- Students make the first entry in their journals.

>> *Wrap-Up* *(10 min., ongoing activity)*
- (Agro) Phenology activity discussion.
- Reflective writing.
- Make and record a new journal entry 1-2 times per week for at least 5 weeks.

Background

According to Nature's Notebook, a citizen science effort managed by the USA-National Phenology Network, "**phenology** is the study of the timing of lifecycle events in plants and animals, their recurrence, and relationship to the environment." It can also be understood as nature's calendar. You know what time of the year of it is by the types and state of the foliage around you, the temperature and weather, and perhaps by the animals and insects that are or aren't present. The success of many major and annual lifecycle events in many plants and animals is dependent on the presence of other plants and animals for, the climate, and the condition of their habitat.

Check out **https://www.usanpn.org/nn/guidelines** to learn more about how to make animal and plant observations for the purposes of phenology.

Procedure

Materials

- Student agrophenology journals
- Writing, drawing, coloring utensils
- Student phones or cameras- Optional
- Tape, staples, etc.- Optional

Set-Up

1. Check out **https://www.usanpn.org/nn/guidelines** so you can explain to your students how to record their plant and animal phenology observations.
2. **Remote or In-person:**
    a. Will students be recording phenology observations in a predetermined agroecosystem used by the group or one of their own deciding? This needs to be decided before the activity.

Introduction (15 min.)

1. Give a brief presentation on phenology and how it relates to climate change, human society, and agriculture.
2. Explain how to begin a phenology journal and how to make phenological observations of plants vs. animals.
    a. First phenology journal entry: Begin with a description of your site, where it's located, what surrounds it, typical climate and expected weather patterns, present plants and animals, and other important details about it's parts and how they interact.

Activity (25 min./Once a Week)

1. Pass out the materials the students will need for this activity: a phenology journal, writing utensils, materials for coloring and taking samples, etc.
2. Instruct your students to take 20 minutes to sit quietly in their potential agroecosystem and phenology site and to record their observations in their phenology journals. They should record the animals they see, their activity, and state; the vegetation that's present and the stages it's in; the weather and whether or not it's typical for this time of year; and any other observations about the living organisms present at their site and how they respond to the climate and other abiotic factors within their site.

Wrap-Up (10 min./Once a Week)

1. After 20 minutes, invite the students to gather together to discuss what they observed at their phenology sites and how they think that information might impact the establishment of an agricultural operation within that site.
    a. Is the weather they experienced typical for that time of year and how might that impact organisms related to agricultural activities?
    b. Did they observe any pollinators at their site and how might that impact agricultural activities?

Additional Resources:

- **Nature's Notebook**- https://www.usanpn.org/natures_notebook
- **Nature's Notebook, Why Phenology?**- https://www.usanpn.org/about/why-phenology

Appendix

Lesson alignments with MN STEM standards

Land-Use & Planning Your Agroecosystem

- **9.1.3.1.** Natural and designed systems are made up of components that act within a system and interact with other systems.
  - Benchmark: 9.1.3.1.1. System Relationships.
  - Benchmark: 9.1.3.1.2. A System vs. it's Parts.
- **9.1.3.3**. Science and engineering operate in the context of society and both influence and are influenced by this context.
  - Benchmark: 9.1.3.3.2 Persuasive Communications Communicate.
  - Benchmark: 9.1.3.3.3 Multi-disciplinary Efforts.

Soil Texture Evaluation: Lab vs. Field

- **8.3.1.2.** Landforms are the result of the combination of constructive and destructive processes.
  - Benchmark: 8.3.1.2.2. Surface processes in Minnesota
- **7.1.3.4**. Emerging Technologies
  - Benchmark: 7.1.3.4.1 Use of Maps & Data Sets
  - Benchmark: 7.1.3.4.2 Procedures for Investigations

IPM & Crop Scouting

- **9.3.4.1.** People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.
  - Benchmark: 9.3.4.1.1 Natural Hazards
  - Benchmark: 9.3.4.1.2 Human Alterations of Earth
- **9.4.2.1.** The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.
  - Benchmark: 9.4.2.1.2 Changes in Ecosystems
- **9.4.4.1.** Human activity has consequences on living organisms and ecosystems.
  - Benchmark: 9.4.4.1.1 Biotechnology Risks & Benefits
- **7.4.2.1.** Natural Systems
  - Benchmark: 7.4.2.1.1 Populations & Communities
  - Benchmark: 7.4.2.1.2 Roles of Organisms

- **7.4.4.1.** Human Activity
  - Benchmark: 7.4.4.1.2 Humans Changing Ecosystems

Playing with Dirt: Soil Structure & Vegetation

- **9.3.4.1.** People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.
  - Benchmark: 9.3.4.1.1 Natural Hazards
  - Benchmark: 9.3.4.1.2 Human Alterations of Earth
- **9.4.4.1.** Human activity has consequences on living organisms and ecosystems.
  - Benchmark: 9.4.4.1.1 Biotechnology Risks & Benefits

(Agro)Phenology

- **6.1.3.1.** Systems
  - Benchmark: 6.1.3.1.1 Subsystems Within Systems.
- **6.1.3.4.** Emerging Technologies
  - Benchmark: 6.1.3.4.1 Investigating Systems
- **7.4.2.1.** Natural Systems
  - Benchmark: 7.4.2.1.1 Populations & Communities
  - Benchmark: 7.4.2.1.2 Roles of Organisms