Best Management Practices

Future of Agriculture Curriculum for Teaching Sustainability

Name: _____ Hour_____Date: _____

Date Packet is due:_____ Why late? _____Score: _____

Day of Week Date If your project was late, describe why

Overview: In this unit, students will investigate how Best Management Practices (BMPs) can be used to improve soil health and productivity.

Main Questions

- To what extent do conventional agricultural practices affect soil health?
- What are examples Best Management Practices and how might they improve soil health?

Weekly Schedule

Monday:
- Watershed Simulation Activity
- Model development – How do different factors affect runoff?

Tuesday:
- Nutshell Video & Notes
- Class discussion & revisions of explanations

Wednesday:
- Interview an Expert Lab

Thursday:
- Review
- Group Quiz

Friday:
- Weekly Reflection
- Career & Community Connections

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Semester Schedule

Week 1: Introduction & Lab Safety

Sustainable Soils

Week 2: Sustainable Ag
Week 3: Soil Science
Week 4: BMPs
Week 5: Unit Project

Plant Physiology

Week 6: Roots
Week 7: Stems
Week 8: Leaves
Week 9: Plant Systems
Week 10: Unit Project

Plant Environments

Week 11: Light
Week 12: Temperature
Week 13: Water
Week 14: Biodiversity
Week 15: Unit Project

Gardening

Week 16: Gardening 101
Week 17: Final Project
Week 18: Final Exam

National Science Foundation WHERE DISCOVERIES BEGIN

MICHIGAN STATE UNIVERSITY®

KBS LTER Kellogg Biological Station Long-term Ecological Research

Day 1: Watershed Simulation Activity

Introduction: In this activity, you will be using a computer simulation to investigate how different soil properties and different soil uses can affect the rate at which water enters the soil (known as *infiltration*) versus the rate at which water moves over the soil and into surface water (known as *runoff*).

Materials Needed: a computer or device with internet access

Directions: *Complete the questions below and follow. Then complete the activity directions on the next page.*

1. As a group, briefly determine what factors might affect whether precipitation is *infiltrated* (or absorbed) into soil or moves across the soil as runoff. List four soil properties that might increase the infiltration of water into the soil and briefly describe why this would be helpful for infiltration.

   1 _____

   2 _____

   3 _____

   4 _____

2. While some soil runoff is unavoidable, usually the goal is to minimize runoff and maximize infiltration. Summarize three potential problems that might occur as a result of overly high rates of runoff.

   1 _____

   2 _____

   3 _____

3. When your instructor determines that all of the groups are ready, discuss your responses as a class. Include anything significant that your group did not consider in the space below.

4. On a device with internet access, visit the following website: https://runoff.modelmywatershed.org
Your screen should resemble the screenshot below:

The **left side of the screen** shows three ways in which precipitation can interact with the soil.
- The top left figure (in blue) indicates the amount of precipitation that falls in centimeters. This can be adjusted using the slider option on the top right of the screen.
- The top right figure (in green) indicates evapotranspiration, or the amount of moisture that travels through plants and evaporates from their leaves.
- The bottom left figure (in red) indicates the amount of runoff that occurs in each case. Generally, we want to minimize runoff as it is a primary cause of erosion and nutrient contamination in waterways.
- The bottom right figure (in orange) indicates infiltration, or the amount of precipitation that is absorbed into the soil. This precipitation may be eventually absorbed by roots or may eventually reach groundwater.

On the **right side**, you can select the amount of rain (top slider w/ the raindrops), the land cover option, and the hydrological soil group (based on particle sizes, which are shown as hexagons in the soil).

5. In your first experiment, you will be testing how different particle sizes (called *hydrologic soil group*) affect rates of runoff and infiltration. In the space below, hypothesize what differences will occur in runoff between the larger and the smaller soil particles.

*I hypothesize that*_____

6. Briefly explain the reasoning for your hypothesis_____

_____

7. Keep the precipitation at 5 cm. Select "Crops" for the Land Cover option. Begin with Option A for the hydrological soil group (the largest soil particles). Then select Option D. Create bar graphs for the results below, with "A – High Infiltration" on the left and "D - Very Slow Infiltration" on the right.

8. Briefly summarize what occurred in the space below.

_____

_____

9. Why do you think that you got these results? Explain using what you know about soil science.

_____

_____

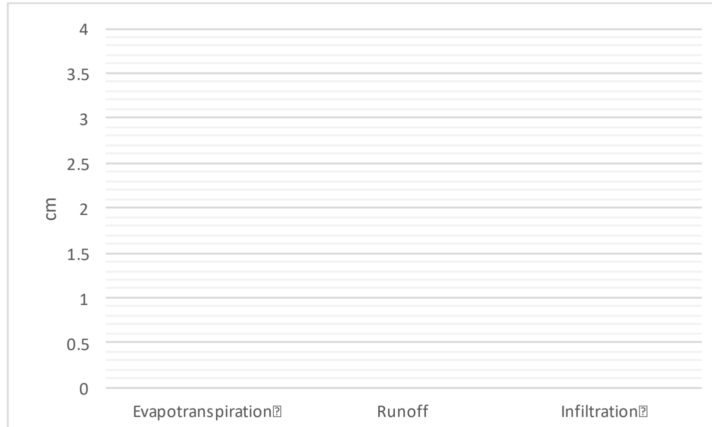
10. In your second experiment, you will be testing how different Land Cover types affect rates of runoff vs. infiltration. You will compare *crops*, *forest*, *developed* (medium), and *wetlands* as shown in the simulation. In the space below, rank these four types of Land Cover based on your predictions for which one will have the most runoff and which one will have the least runoff.

Most Runoff: _____ Least Runoff: _____

11. Briefly explain the reasoning for your hypothesis_____

_____

12. Keep the precipitation at 5 cm. Select "Crops" for the Land Cover option. Begin with Option B for the hydrological soil group (moderate infiltration). First, record the results for Crops. Then change Land Cover to Forest. Repeat this for Development (Med) and Wetlands. Create bar graphs for the results below. Be sure to label each graph for which Land Cover it represents.



13. Did these results support your hypothesis? Explain:

____

____

14. Why do you think that you got these results? Explain using what you know about soil science. Be sure to consider the role that vegetative cover and soil disturbances might have played in these scenarios.

____

____

____

15. In your final experiment, compare the rates of runoff and infiltration for Option B for the hydrological soil group (moderate infiltration) between Crop and Grassland Land Cover options. If every farmer in an area agreed to put grassland habitat strips between their fields and aquatic habitats (such as lakes, rivers, and streams), how might this affect the amount of contamination from runoff into those aquatic habitats?

    I think that adding grassland strips would *increase / decrease/ not affect* (circle one) the amount of

    runoff into aquatic habitats because _____

    _____

16. What patterns did you notice as you were completing this activity? What factors increased the rate of runoff? Briefly describe three factors (such as soil particle size, level of vegetation, etc.):

    1 _____

    2 _____

    3 _____

17. Imagine you are part of a taskforce that has the goal of minimizing water contamination in local rivers, lakes, and streams in a small rural community. Based on these findings, what recommendations would you make? Briefly describe three options that would help achieve this objective. Then describe why it might help:

    1. _____

    _____

    2. _____

    _____

    3. _____

    _____

18. If time allows, be prepared to discuss your findings and conclusions as a class. Use evidence-based argumentation to reach a consensus (if possible) the helps to explain why the different soil types and different types of land cover resulted in the observed changes to runoff and infiltration.

Day 2: Notes & Discussion

Introduction & Directions: In this activity, you will begin by watching a short video about soil management practices. This will help to clarify some of the questions you may have had yesterday. After the video, you will look at a short slideshow presentation that will provide you with specific information about Best Management Practices. Your instructor may decide to deliver the presentation as a classroom lecture or they may allow you to read the notes individually or in small groups (depending on your previous experience and capabilities with this content). After you have watched the video and finished with the slideshow, you will work in small teams to answer the questions listed below. You should take notes in a notebook, online, on a dry erase board, or on scratch paper so that you are prepared to deliver your responses during the class discussion that will follow. *Note: your instructor may assign your group to answer specific questions if time is limited.*

URL Links
YouTube Video: https://www.youtube.com/watch?v=irTg1f9ic38

Slideshow Presentation: XXXX (or visit www.factsnsf.org and use the menu bar).

Discussion Questions:

1. What is a healthy soil?
2. What are some factors that determine the health of soil?
3. How do different kinds of agriculture differ in regards to what soil properties they prioritize?
4. Summarize the benefits of healthy soils.
5. Define water infiltration and carbon sequestration and summarize how these properties affect soil health.
6. Do modern agricultural practices in the US generally support healthy soils? Justify your stance with evidence.
7. What are BMPs?
8. What are some reasons for why farmers should consider adopting BMPs?
9. Summarize four principles for maintaining soil health through BMPs.
10. Summarize each of the following and describe how they improve soil health: 1) Nutrient Management; 2) Crop Rotation; 3) Conservation Tillage; 4) Cover Crops; 5) Conservation Buffers
11. Do BMPs apply to gardeners and home owners? Explain.

Day 3: Lab - Interview an Expert

Introduction: In this activity, you will have an opportunity to interview an individual with professional expertise in this week's content topics. This activity will be reflective of *social science* research, or gathering, analyzing and interpreting information about human interactions. Often this work is conducted using *qualitative interviews*, which are interviews designed for research and data collection.

This activity will be divided into three parts:

1. **Part 1 – Planning**: After your instructor describes today's guest speaker, your group will identify your research question using the prompts below. Your research question should pertain to the topics covered in class this week. Based on your research question, you will develop questions that might help you to gather information that can help you to answer your research question. Your instructor will ask your group to share your research question and interview questions prior to the interview and make sure that a variety of questions are ready.
2. **Part 2 – Interview**: Your instructor will facilitate the interview; they may choose to ask groups to ask their questions in a specific order (semi-structured approach), or they may choose to use an unstructured approach to the interview. Your group should record fields notes during this time that you will use at the end of the hour to address your research question.
3. **Part 3 – Analysis & Debrief**: You will be provided with some time to consider the responses that they receive and reach a tentative conclusion about their research question based on this data.

Part 1 - Planning:

1. Briefly summarize the topics that were covered in class this week in one sentence: *This week in class,*

   we studied _____

   _____

2. As a group, discuss what questions you still have about this week's topics. Ideally, these questions should be open-ended (try to avoid Yes/No, Good/Bad, or Agree/Disagree kinds of questions). It can be helpful to use some of the following to start your questions: *Who, What, When, Where, Why, How*

   1. _____

   2. _____

   3. _____

   Once you have developed three questions, ask for your instructor to provide you with some feedback.

3. From this list, choose a research question for your group and complete the prompt below:

   Research Question: *We are unsure if* _____

   _____

4. Turn your research question into a hypothesis. What do you think is the answer to your research question given what you currently know?

   We hypothesize that _____

   _____

5. What information could today's guest speaker provide that might help you to answer your question? Briefly describe how this individual's background and expertise is relevant to your research question:

   _____

   _____

6. Create three interview questions that you could ask this individual that may provide information related to your research question. Try to focus on their particular area of expertise as you craft your questions.

   1. _____

   2. _____

   3. _____

7. Be prepared to briefly describe your research question and hypothesis, and how your interview questions will provide you with information that will help to address your research question.

Part 2 – Interview Field Notes

Use the space below to record some field notes as the guest speaker presents to the class. Record anything that you hear or observe that might be relevant to your research question. Note: you should also consider recording the guest speaker's responses to other group's questions if they are relevant to your own research question.

_____

_____

_____

_____

_____

_____

_____

Part 3 – Analysis & Debrief *(your instructor may choose to use oral responses as well as or instead of written)*

What are your conclusions based on the guest speaker's responses? Answer the questions below.

1. What was your hypothesis?_____

2. Does your data (your observations and field notes from your interview with the guest speaker) support or refute your hypothesis? Circle one: *Supports it* / *Refutes it* / *Not sure*

   Explain: _____

3. Does your data adequately answer your research question? What are the limitations of your findings? Could *bias* or *representativeness* be a concern? (*Ask you instructor for guidance if needed*).

4. List two new questions that emerged as a result of your interview today:

   *1*_____

   *2*_____

5. If you were to continue this work, what kinds of investigations would you do next? Describe a potential research experiment that would be a suitable follow-up for today.

Day 4: Review & Assessment

Directions: you will begin by reviewing the unit objectives in your small groups. For each objective, rank it as a 1 (*completely unsure*), 2 (*somewhat unsure*), or 3 (*completely sure*) based on your comfort with that objective. After a few minutes of review, your instructor will lead a whole-class review. This is your chance to ask any questions you still might have about the concepts in this unit. Begin with anything you ranked as a "1".

After you have completed the unit review, you will be taking an individual multiple choice quiz and/or a group short answer quiz. These quizzes may be graded in class to help you better understand the question and the correct answer.

Unit Objectives:

1. What is a healthy soil?
2. What are some factors that determine the health of soil?
3. How do different kinds of agriculture differ in regards to what soil properties they prioritize?
4. Summarize the benefits of healthy soils.
5. Define water infiltration and carbon sequestration and summarize how these properties affect soil health.
6. Do modern agricultural practices in the US generally support healthy soils? Justify your stance with evidence.
7. What are BMPs?
8. What are some reasons for why farmers should consider adopting BMPs?
9. Summarize four principles for maintaining soil health through BMPs.
10. Summarize each of the following and describe how they improve soil health: 1) Nutrient Management; 2) Crop Rotation; 3) Conservation Tillage; 4) Cover Crops; 5) Conservation Buffers
11. Do BMPs apply to gardeners and home owners? Explain.

Day 5: Career Connections

Directions: Begin with a group and class discussion about the topics of this week. What is still unclear? What is still confusing? What seemed most important to remember? How does this relate to horticulture?

If time allows, you will also have time to work on one or two semester projects:

The Garden Project involves creating your own garden as a group. Your instructor will provide you with more details, but in a nutshell you will work as part of a team to plan, design, and create some kind of garden. This might be a community garden, a school-based garden, or a container garden. The goal is to utilize the knowledge and practices that you gain over the course of this semester to maximize the productivity and sustainability of your garden.

The Adopt a Farmer Project involves working with a farm, greenhouse, or community garden in your community in order to determine some new methods that they could try to improve the sustainability of their operation. Your instructor will provide you with more details about this project.

Soil Science Individual Quiz

Name: _____Hour_____Date:_____Score:_____/___

Directions: This quiz should be completed on an individual basis. A 3x5 notecard with handwritten notes can be used on this quiz.

1. **Which of the following best describes characteristics of a healthy soil?**
    a. Nutrient levels (such as nitrogen and phosphorus) are kept as high as possible to maximize plant growth.
    b. The presence of plants is minimized to prevent excess reductions to soil nutrients.
    c. The soil has nutrient levels that are sufficient but not excessive; biodiversity and organic matter in the soil is maximized.
    d. Biodiversity in the soil is kept minimal to prevent excess reductions to soil nutrients.

2. **This form of agriculture primarily focuses on maintaining soil nutrients and biodiversity.**
    a. Industrial b. Sustainable c. Regenerative d. All of the above

3. **This form of agriculture primarily focuses on improving soil nutrients and biodiversity.**
    a. Industrial b. Sustainable c. Regenerative d. All of the above

4. **This form of agriculture primarily focuses on increasing nutrient levels in the soil.**
    a. Industrial b. Sustainable c. Regenerative d. All of the above

5. **This form of agriculture depends on healthy soils to be profitable and functional.**
    a. Industrial b. Sustainable c. Regenerative d. All of the above

6. **Which of the following is NOT a property of healthy soil?**
    a. Similar levels of sand, silt, and clay.
    b. Roughly 50% porespace and crumbly aggregates.
    c. Minimal organic matter.
    d. Slightly acidic soil pH.
    e. Diverse soil microbial communities.

7. **Which of the following is NOT an outcome associated with healthy soil?**
    a. Improved crop productivity
    b. Reduced erosion
    c. Reduced weeds and pests
    d. Less water infiltration
    e. Reduced need for fertilizer and pesticides

8. **This describes the rate at which water moves from the soil surface into the soil porespace.**
    a. Carbon Sequestration b. Plant Residue c. Best Management Practices d. Infiltration

9. **This refers to a series of agricultural practices that can maintain agricultural productivity and profitability while minimizing the negative environmental consequences of food and fiber production.**
    a. Carbon Sequestration b. Plant Residue c. Best Management Practices d. Infiltration

10. **This is the capacity of soil to store carbon-based molecules, slowing the production of CO_2.**
    a. Carbon Sequestration b. Plant Residue c. Best Management Practices d. Infiltration

11. **Which of the following is FALSE?**
    a. The current rate of erosion is ten times greater on average than the rate of soil formation.
    b. An acre of Midwestern cropland loses an average of 1000 lbs. of soil organic carbon per year.
    c. Agriculture is the leading cause of water contamination in the US, primarily because of runoff from farm fields.
    d. Modern agricultural practices generally reduce soil microbe biodiversity, resulting in deceased long-term productivity.
    e. None of the above are false.

For each of the following, summarize what these practices mean in your own words and include an example in each case.

12. **Minimize disturbances:** _____

_____

13. **Maximize soil cover:** _____

_____

14. **Maximize biodiversity:** _____

_____

15. **Maximize presence of living roots:** _____

_____

16. **These are strips of vegetated land between cropland and native habitats or surface water.**

a. Conservation Tillage; b. Cover Crops; c. Crop Rotation; d. Nutrient Management; e. Conservation Buffers

17. **These are crops planted after the primary crop to reduce erosion, control weeds, and increase biodiversity.**

a. Conservation Tillage; b. Cover Crops; c. Crop Rotation; d. Nutrient Management; e. Conservation Buffers

18. **This practice involves planting different crops in a rotating sequence year after year.**

a. Conservation Tillage; b. Cover Crops; c. Crop Rotation; d. Nutrient Management; e. Conservation Buffers

19. **This is a practice which matches fertilizer application to a field with a crop's need for nutrients.**

a. Conservation Tillage; b. Cover Crops; c. Crop Rotation; d. Nutrient Management; e. Conservation Buffers

20. **This practice leaves soil and crop residue undisturbed for as long as possible by minimizing the use of plowing.**

a. Conservation Tillage; b. Cover Crops; c. Crop Rotation; d. Nutrient Management; e. Conservation Buffers

Soil Science Group Quiz

Names (F&L): _____

_____Hour_____Date:_____Score:_____/___

Directions: This quiz should be completed in your assigned groups. A 3x5 notecard with handwritten notes can be used on this quiz. Each person should take turns writing an answer. Those not writing should be actively working together to create their group's answer. Those who are not actively involved in answering every question may be asked to complete this quiz alone. Record the writer's name after each question.

1. **Damien argues existing agricultural practices are sufficiently sustainable. He cites decades of improving agricultural productivity as evidence that how US farmers produce food supports soil health. Mariela disagrees. She claims that the way in which farmers are currently producing food will not last for more than a few more decades at most before massive soil depletion seriously impairs food production. Do you agree more with Damien or Mariela? Use evidence to support or refute these arguments in the space below.**

Writer's Name:

2. **What are Best Management Practices (BMPs) in agriculture? Briefly summarize this term in the space below and describe the benefits of utilizing these practices.**

Writer's Name:

3. **A farmer is concerned about the impact of some of the conventional practices that she has been using to produce her crops. In particular, she has noticed decreasing rates of infiltration. This has reduced the ability of her crops to tolerate periods of drought. She is also concerned about the effects of runoff in a nearby stream. She has heard of BMPs but is concerned that adopting these practices might impair her crop's productivity, which might mean she won't be able to generate enough income to pay for all of her expenses. In the space below, summarize three BMPs that might address these concerns. Justify how these practices would be beneficial.**

1. _____

_____

_____

2. _____

_____

_____

3. _____

_____

_____

Writer's Name:

4. **For each of the following, summarize what these practices mean in your own words and include an example in each case.**

Minimize disturbances: _____

_____

Maximize soil cover: _____

_____

Maximize biodiversity: _____

_____

Maximize presence of living roots: _____

_____

Writer's Name:

Appendix: Watershed Simulation Lab

Introduction: The purpose of this activity is to enable students to develop explanatory models that connect soil particle size and land cover to rates of runoff and water infiltration into the soil.

Directions: Students should be able use the step-by-step instructions in the packet to complete the activity. You may want to model this first step of this activity using a computer projector if your students need additional support. You should also consider your students' abilities to graph data and understand its meaning. Those with less experience using visual quantitative data will likely need assistance throughout this activity and may benefit from you modeling your thinking in a demonstration.

Students should be guided between individual, group, and whole-class discussions during this activity. This activity works best in a "divergence-to-convergence" approach – i.e. allow individual students and groups to consider a broad range of possibilities, and then guide them in narrowing their ideas using evidence to separate evidence-based conclusions from those not supported by evidence.

It would be helpful to connect back to this activity throughout the rest of the week to support student comprehension about the need and benefits of each kind of Best Management Practice. It would also be helpful to solicit student input about their own observations in regards to these different scenarios in the activity. For example, have they noticed a difference between highly vegetated areas, bare soils, and highly-developed areas during or after a major rainstorm? Students have likely observed more flooding in urban/suburban areas with lots of pavement but less so in areas with higher amounts of native habitat. Similarly, students may have observed larger amounts of erosion in fields with bare soil in comparison to fields with larger amounts of vegetation.

Students may struggle a bit with particle sizes and rates of runoff. While large soil particles like sand are more prone to erosion, they are also able to allow more water infiltration. Conversely, small soil particles like clay are less prone to erosion but also allow less water infiltration, resulting in more runoff across the soil instead of infiltration into the soil.

Appendix: Interview an Expert

Introduction: In this activity, students will interview a member of your community with expertise in agriculture and/or sustainability. Examples could include local farmers, extension agents, researchers, etc. As an instructor, you will need to make arrangements for a guest speaker at least a week in advance (ideally sooner). Once you have found a volunteer who is willing to speak to your class, please inform them that this class activity is being designed to reflect how social scientists conduct research. Your guest speaker should know that students will be preparing research questions and hypotheses, and will be designing their interview questions to provide insights that may help them to address these questions in a manner similar to a social scientist.

This activity will be divided into three parts:

1. **Part 1 – Planning (15-20 min)**:
    a. Inform students of the guest speaker (or introduce them if they are there in person). Explain how their work pertains to this week's content.
    b. Have student groups identify their research question using the prompts on the worksheet. Their research question should pertain to the topics covered in class this week. Remind students that questions should be thoughtful, insightful, and respectful. You should provide examples to students if they might struggle with this.
    c. Have groups share your research question and interview questions prior to the interview and make sure that a variety of questions are ready.
2. **Part 2 – Interview (15-20 min)**:
    a. Serve as the facilitator of the interview. You may choose to ask groups to ask their questions in a specific order (semi-structured approach), or you may choose to use an unstructured approach to the interview.
    b. Remind groups to record fields notes during this time to use at the end of the hour to address their research question.
3. **Part 3 – Analysis & Debrief (10 min)**:
    a. Have students address their hypothesis using their observations and field notes. This can be either verbal, oral, or both depending on what you think will work best.

It is recommended that you introduce this activity to your students earlier in the week (e.g. Monday or Tuesday) so that they can begin to mentally prepare their research questions in advance. Make sure that your students avoid turning this activity into something that might feel accusatory or incriminating to the guest speaker (especially if they are a farmer – they may not appreciate having their expertise and experience drawn into question by teenagers). Emphasize that this should be a respectful exercise in finding information by asking thoughtful questions, not an opportunity to criticize an individual for their work.

The guest speaker can either appear in person or via an online platform such as Skype. An in-person guest speaker tends to be more impactful but can be harder to arrange. You may choose to ask an introductory question to model a proper approach for your students. Whether students ask their questions in a specific order or utilize a free-for-all approach to asking questions is up to you as the instructor. Time may run short, but if possible allow time at the end of class for debriefing and analysis (ideally at least 10 minutes). You might choose to have students answer the Analysis and Debrief questions orally rather than in writing to save time if that would be helpful. It is also an option to postpone the Analysis and Debrief to a later day.