Soils Unit Project

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 design the "ideal garden" by considering how they might maximize soil health and plant productivity through their choice of management practices.

Main Questions

- How can regenerative soil health be maximized in a garden setting?
- How can soils be managed in a garden to sustainably maximize plant productivity?
- What data and tests are necessary to confirm that soil health and productivity will be sustainably and regeneratively maximized?

Weekly Schedule

Monday:
- Intro to Soils Unit Project

Tuesday:
- Soils Unit Project Work Time

Wednesday:
- Finish Soils Unit Project; Begin Presentations

Thursday:
- Complete Soils Unit Project Presentations
- Review

Friday:
- Individual Midterm Exam – Sustainable Soils Unit

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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

Day 1: Intro to the Soils Unit Project

Introduction: In this project, you will work in groups of 3-5 to develop a presentation describing how you would maximize soil health in order to increase plant productivity in a garden. You should use a presentation program (such as Microsoft PowerPoint or Google Docs) to address the items below.

Background: As a group, you will be designing the ideal garden that sustainably and regeneratively maximizes plant growth and productivity. For this particular project, you will be focusing on soils and on practices that maximize soil health. Your primary goal is to ensure that the crops you plant in your garden are sustained by soils that have ideal conditions in regards to particle size, infiltration, organic matter, and other factors. You will need to describe what soil conditions would be ideal, what management practices are needed to sustain and regenerate these conditions, and what tests could be performed to confirm these conditions are present in your garden's soil.

You and your group (if you have one; you can work alone) should address the following in your paper:

1. **Introduction** – What is soil and what role does it play in plant growth and productivity?
    a. What are soils? What is in soil? Where do soils come from and how do they form?
    b. Summarize how soils support and enable plant growth and productivity.
    c. What does it mean to use soil in a sustainable and regenerative manner?
    d. In what ways can you measure soil health in order to confirm that soil is being used in a manner that is regenerative and sustainable? Summarize what data you would need to confirm this.

2. **Soil Science** – How do different soil properties relate to plant growth and productivity?
    a. Briefly summarize each of the following soil properties and summarize what these properties look like in an "ideal" soil: a) Texture; b) Cation Exchange Capacity; c) Soil pH; d) Structure; e) Soil Nutrients; f) Soil Organic Matter; g) Soil Microbes; h) Color
    b. Explain the role that each of these properties serve in promoting plant growth and productivity.
    c. In what ways can you measure these soil properties in order to confirm that a given sample of soil is ideal for sustainable plant productivity?
        i. Summarize what data you would need to confirm this.

3. **Best Management Practices** –
    a. Summarize how biodiversity, ecosystem services, ecosystem resilience, and human populations are affected by each other.
    b. Briefly list and summarize the three kinds of sustainability and explain how to determine if an action is sustainable or unsustainable.
    c. How do we know if soils are healthy? How do we know if they are being used in a sustainable and regenerative way?
    d. What practices will be adopted in your garden to support the goal of maximizing plant growth and productivity in a sustainable and regenerative manner?
        i. Summarize what data you would need to confirm this.

Grading: Your grade will be determined using the following considerations:

Item	*Plus (100%)*	*Check (70-90%)*	*Redo (0%)*
Accuracy	No errors were detected in this work	This work contained a few errors, but overall was very accurate.	This work contained considerable errors.
Thoroughness	No important information was omitted.	A few more details would have enhance this work.	Major topics were omitted that should have been included.
Applicability	This work could be used in real life without any expectation of problems.	This is acceptable work for high school students but there is a chance that this would not be completely suitable for real life.	This work is not applicable to a real-world situation and falls below the expectations for a high school student in this class.
Professionalism	This work is completely free of errors in regards to spelling, grammar, word use, vocabulary, plagiarism, etc.	While this is acceptable work, there were at least a couple errors in regards to spelling, grammar, word use, vocabulary, plagiarism, etc.	Repeated errors were found errors in regards to spelling, grammar, word use, vocabulary, plagiarism, etc.
Effort	Effort exceeds what would be expected of a high school student.	Effort is acceptable for a high school student but room exists for improvement.	Level of effort could have been much greater than what was presented.

A peer review may also be used to ensure that all group members have contributed equally to this work. Your individual grade may be raised or lowered from the group score if you have a very high or very low peer review score in comparison to the rest of your group members.

Day 2-3: Work Time

Introduction & Directions: Use this time to complete your group presentation. Remember that you're not done until your group is completely finished. If you finish your portion of the presentation, help other group members complete their portion, check the presentation for errors, or add additional components to your presentation to improve its professionalism and appeal.

Day 3-4: Unit Project Presentations

Introduction: Your instructor will provide you with details about how each group will present their work. They may choose to have groups present in front of the whole class, separately from the class, or in another format.

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".

Sustainable Agriculture Unit Objectives:

1. Summarize how biodiversity, ecosystem services, ecosystem resilience, and human populations are affected by each other.
2. Explain how the US Midwest is able to produce large amounts of food and support extensive human activity by addressing the following considerations: temperature, moisture, sunlight, photosynthesis.
3. Explain why regions of the world such as tundra and alpine regions are more fragile ecosystems and why they are less able to support large amounts of human activity.
4. How do human-caused ecosystem disturbances affect an ecosystem's ability to support human activity? Include the term "biodiversity" in your response.
5. How can you determine if an action is sustainable or unsustainable?
6. Briefly list and summarize the three kinds of sustainability.
7. What is the Triple Bottom Line of Sustainability?
8. In your opinion, are modern agricultural practices sufficiently sustainable? Could these practices continue for centuries? Justify your stance with evidence.
9. Define sustainable agriculture in your own terms and summarize how modern agricultural practices could become more sustainable based on the criteria provided in this lesson.
10. How is regenerative agriculture similar and different from sustainable agriculture?
11. Summarize the principles of regenerative agriculture?
12. What are the agricultural Best Management Practices? How are they similar and/or different from sustainable agriculture and regenerative agriculture?
13. What are the agricultural UN Sustainable Development Goals? How are they similar and/or different from sustainable agriculture and regenerative agriculture?
14. Use the example of the Dust Bowl in the United States during the 1930s to explain how human populations are affected when unsustainable practices impair biodiversity and ecosystem services.

Soil Science Unit Objectives:

15. What are soils? How are soils created? How long does this process take?
16. How do soils support and enable plant growth and productivity?
17. Briefly describe the three primary kinds of soil particles and their comparative sizes.
18. What is a loam?
19. What type of soil particle is ideal for plant growth and productivity?
20. How does the size of a soil particle relate to its surface area?
21. What is soil compaction? What is porespace?
22. How does soil particle size relate to each of the following? 1) Compaction; 2) Porespace; 3) Nutrient losses due to runoff; 4) Ease of nutrient absorption by plants
23. What is the cation exchange capacity (CEC) of soil? Why is this important?

24. How does soil particle size relate to CEC? How does soil leaching relate to CEC?
25. What is soil pH and why does it matter?
26. Briefly define each of the following and describe how they are related: 1) Soil structure; 2) Aggregates; 3) Granular soil
27. How can you tell if a soil sample has an appropriate amount of soil structure? What problems can occur if soil does not have appropriate soil structure?
28. True or false: plants depend on soil for their food. Explain.
29. Briefly describe the three key nutrients that soil provides to plants and describe their role in plant growth & productivity.
30. Briefly describe each of the following and how they are related: 1) Soil Organic Matter; 2) Humus
31. What are five benefits provide by SOM that improve plant growth and productivity?
32. What are four key benefits provided by abundant and diverse soil microbial communities?
33. What most affects whether or not soil microbial communities are abundant and diverse?
34. How does the color of soil relate to the health of the soil? Explain.
35. In your own words, describe 7 ways to assess the health of a soil sample and its capacity for enabling plant growth and productivity.

BMP Discussion Questions:

36. What is a healthy soil?
37. What are some factors that determine the health of soil?
38. How do different kinds of agriculture differ in regards to what soil properties they prioritize?
39. Summarize the benefits of healthy soils.
40. Define water infiltration and carbon sequestration and summarize how these properties affect soil health.
41. Do modern agricultural practices in the US generally support healthy soils? Justify your stance with evidence.
42. What are BMPs?
43. What are some reasons for why farmers should consider adopting BMPs?
44. Summarize four principles for maintaining soil health through BMPs.
45. 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
46. Do BMPs apply to gardeners and home owners? Explain.

Sustainable Soils Unit Midterm Exam

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. **Define sustainable agriculture in your own words and summarize the characteristics that you would use to determine if a farm's operations were sufficiently sustainable. Be sure to fully address the Triple Bottom Line of Sustainability.**

2. **Which of the following best describes how soils are formed?**
   a. As plants and animals break down, the carbon in their bodies turns into minerals that plants eat to survive.
   b. Over thousands of years, rocks are weathered down to small particles that mix with small amounts of decaying organic matter and living organisms.
   c. As animals consume plants, they convert the plant matter into minerals. The feces from the animals then forms the soil.
   d. Over thousands of years, carbon dioxide in the air converts into minerals that fall to the ground and form soil.

3. **This has the smallest amount of porespace for air and water.**
   a. Clay b. Silt c. Sand d. Loam

4. **This is the least likely to undergo compaction but is at most risk for erosion.**
   a. Clay b. Silt c. Sand d. Loam

5. **This is the most ideal soil for plant growth and productivity.**
   a. Clay b. Silt c. Sand d. Loam

6. **The higher the cation exchange capacity (CEC) of a soil sample, the…**
   a. Weaker the soil's capacity is to hold onto water and nutrients.
   b. Stronger the soil's capacity is to hold onto water and nutrients.
   c. Greater the risk of nutrient leaching.
   d. Greater the porespace.

7. **How do factors such as porespace and compaction of soil affect plant growth?**
    a. Compacted soils reduce the availability of water and oxygen to plant roots.
    b. Soils with large amounts of porespace enable roots to absorb more water and soil.
    c. Soils with small amounts of porespace are less likely to undergo nutrient leaching.
    d. Compacted soils have less porespace, which reduces the availability of water, nutrients, and oxygen.
    e. All of the above are accurate statements.

8. **An ideal soil structure would be…**
    a. Clumpy – it easily forms aggregates that hold their shape.
    b. Loose – the soil does not form aggregates and does not hold its shape at all.
    c. Granular – the soil forms small crumbly aggregates.
    d. Solid – the soil is impermeable, like cement.

9. **This the nutrient that plants depend upon most for water uptake.**
    a. Nitrogen b. Phosphorus c. Potassium d. All of the above e. None of the above

10. **This the nutrient that helps plants form the amino acids needed to assemble proteins.**
    a. Nitrogen b. Phosphorus c. Potassium d. All of the above e. None of the above

11. **This is what plants consume as their primary source of food and energy.**
    a. Nitrogen b. Phosphorus c. Potassium d. All of the above e. None of the above

12. **Which of the following is NOT something that is provided by soil organic matter?**
    a. Increases the amount of porespace in the soil.
    b. Provides greater access to nutrients in the soil.
    c. Reduces the risk of both erosion and compaction.
    d. Serves as a source of food for the plant.
    e. Sequesters carbon in the soil, reducing the amount of atmospheric greenhouse gases.

13. **Which of the following is the most important determinant of the biodiversity and abundance of soil microbial communities?**
    a. Particle size b. Availability of NPK c. Porespace d. Abundance of soil organic matter

14. **In general, the _____ the biodiversity of soil microbes, the better.**
    a. Greater b. Lower

15. **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 in the soil is maximized.
    d. Biodiversity in the soil is kept minimal to prevent excess reductions to soil nutrients.

16. **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.

17. 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, resulting in drier soils
e. Reduced need for fertilizer and pesticides

18. 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

19. 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

20. 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.

21. Minimize disturbances: _____

_____

22. Maximize soil cover: _____

_____

23. Maximize biodiversity: _____

_____

24. Maximize presence of living roots: _____

_____

25. 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

26. 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

27. 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

28. 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

29. 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

30. 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 increasing rates of runoff. 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. _____

_____

_____