

Environmental Science for a Changing World

Oak Meadow Teacher Manual

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Introduction

For as long as humans have existed on Earth, we have interacted with and had an impact on the environment. In this course students will learn that environmental science is an interdisciplinary science. Just as our impact on the planet extends into every area of life, this course combines ideas and principles from many subject areas. In a nutshell, environmental science is about how everything is connected to everything else. This will be a common theme throughout the course, and you will see that the topics of the lessons overlap and intertwine.

The textbook for this course is *Environmental Science: Your World, Your Turn* by Jay Withgott (Pearson, 2011). In addition, students will read passages from Aldo Leopold's classic of environmental literature, *A Sand County Almanac*. This course also makes good use of technology and the vast resources found online. If you don't have internet service at home, your student is encouraged to do the online activities at a local library. If no internet access is available, you can help your student identify alternative resources and adapt assignments as needed. Lastly, it is highly recommended that students keep a globe or a world map handy at all times.

There are many hands-on activities and labs in this course, most of which use household items. You will find a full materials list (sorted according to lesson and alphabetically) in the appendix of the student coursebook. This will help you and your student plan ahead so that all the necessary materials are on hand when needed.

There is an assignment summary checklist at the beginning of each lesson in both the student coursebook and your teacher manual. Encourage your student to use the checklist to check off assignments that have been completed and keep track of what still needs to be done. This can help your student develop time management skills and keep his or her work organized.

In this teacher manual you will find the full text for all assignments and most (if not all) the text for activities and labs (for the full text and additional lesson material, see the student coursebook). Teacher manual answers are seen in red. If more information is needed about any assignment, you can refer to the textbook or additional reading material in the student's coursebook. You are also encouraged to familiarize yourself with the lesson structure and appendix resources and to read the introduction in the student coursebook. This can help you better support your student's learning.

The questions in the coursebook are designed to be answered using information from the textbook readings. No additional research is needed unless otherwise stated. In fact, though students can be tempted to look up answers online, this is strongly discouraged, as it often takes the material out of context and does not contribute to a solid understanding of the material.

Students may choose to find online videos to help explain some of the topics. There are many great videos available, and several are included in these lessons. Watching these is encouraged if it helps a student to visualize a concept.

If you are homeschooling independently, this teacher manual can serve as your support as you guide and evaluate your student's work. When a student gets a factual answer wrong, you can share the correct answer and address any underlying misconceptions. The focus should always be on the learning process rather than on a sense of judgement. Several incorrect answers related to a particular topic point to an area the student will benefit from revisiting.

For obvious reasons, it is best not to share this teacher manual with your student. Each student is expected to produce original work, and any incidence of plagiarism should be taken very seriously. If you notice a student's answers matching those of the teacher manual (or a resource book or website) word for word, a discussion about plagiarism and the importance of doing original work is necessary. While students in high school are expected to be well aware of academic honesty, some confusion may exist, so any discussion about it should be approached as a learning opportunity. Make sure your student is familiar with when and how to properly attribute sources.

We encourage you and your student to explore the topics introduced this year through dynamic exchanges of ideas, relevant field trips, viewing and discussing films and videos related to course topics, and in other active, experiential ways. We hope this course leads your student to become a dedicated steward of our planet Earth.

Lesson 4:

Exploring an Ecosystem

Field Activity

Learning Objectives

- Survey an area of land, documenting the physical features and organisms living there.
- Create a detailed site map.
- Identify possible relationships between the organisms in your environment.

ASSIGNMENT SUMMARY

- Conduct the field activity: Exploring an Ecosystem.
- Answer analysis and extension questions.

Field Activity: Exploring an Ecosystem

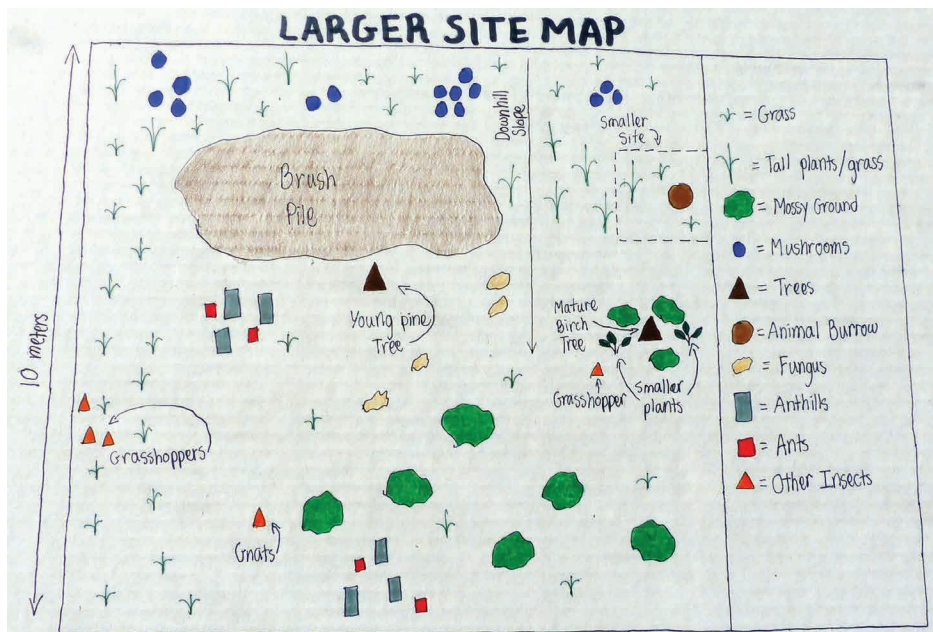
Read through the following procedure and assemble your materials before you begin.

Students will submit all parts of this project. This is good practice with writing a thorough lab report, and focusing on an organized presentation. Reward any effort toward quality work. Any extra research is welcome. Field guides are available in libraries, and students can also look for online field guides. Answers to the questions will vary depending on the site chosen.

Procedure

1. Find an area where you can mark off a 10 meter x 10 meter site to study. Try to choose a place where you are likely to encounter a diversity of life. Place one stake at each corner of the site. Use the string, looping it around each stake, to connect the stakes, marking off the boundaries of your site.
2. In your field notebook, record the date and the weather when you conduct your observations.
3. Examine your site. In your notebook, prepare a site map of the physical features of your site. Show the location of streams, puddles, large rocks, sidewalks, trails, etc. Also, indicate the direction of any noticeable slope. Be sure to note the dimensions of your site on your map.
4. Now create a set of symbols to represent the organisms at your site. For example, you may want to use brown circles to represent trees, red dots to represent insects, blue triangles to represent flowers, green splotches to represent bushes, etc. Include any animal burrows, nests, animal droppings, or tracks that you see. You can also use shading to represent consistent physical features or plant life (such as a sidewalk or grass).

5. Draw your symbols on your site map, showing the relative location and abundance of each type of organism. To the side or at the bottom of your site map, include a key for your symbols.
6. If you need to make additional notes about the organisms present, record them in your notebook. For example, you may want to add additional information about the specific kinds of organisms (e.g. there are three types of moss, or there are several types of tall weeds).
7. In your field notes, also record observations about what organisms are doing. For example, an insect may be eating on a plant leaf, or a lizard could be hiding under a rock. Take additional notes about the physical characteristics of your study area, including but not limited to the following:
 - a. **Sunlight exposure:** How much of the area is exposed to sunlight?
 - b. **Rain/precipitation:** When was the last recorded rain or snow in this area? How much rain was received?
 - c. **Water drainage:** Is the area well drained? Does the soil absorb any rainfall or irrigation, does it flow down the slope, or is there any standing water?
 - d. **Vegetative cover:** How much of the area is covered by vegetation, and how much of the soil is exposed?
 - e. **Maintenance:** Is the area maintained? If so, do you know how often the area is watered, fertilized, mowed, or treated with pesticides?



Credit: Jamie Masthay, Oak Meadow student, 2014

8. Now find a 2m x 2m area within your larger site that you would like to study in more detail. Stake out this area, and mark the boundaries of it with string. Draw the location of this smaller site on your larger site map.
9. Trying not to disturb the site, get right down on the ground and use your hand lens to inspect the area. Record the types of insects, plants, or other features that you see when looking close up.
10. Carefully collect a small sample of soil, and observe it with your hand lens. Describe the soil and any organisms you see living in it. Is the soil mostly sand, silt, clay, or is it loam? Is there organic matter in the soil?
11. *Extra credit (optional)*: Prepare another, more detailed site map of your smaller site. Include a key specifically for this site.
12. If possible, take photos of your site, including close-ups of insects or plants that you can use to help you with identification later. These photos will also give you a comparison for when you revisit this field activity later in the course.
13. Look around at the area around your site. From a general visual survey, are there differences in the physical features or plant/animal life in the surrounding area compared to your site? Or is the entire area fairly uniform? Take brief notes on your observations; you will be answering this more fully in the analysis below.

Analysis

1. Using your field guides, identify as many of the plants or animals as you can.
2. Using your notes and your site map, prepare a written description of your 10m x 10m site. Write one paragraph.
3. Now describe the 2m x 2m site that you studied. Is this site characteristic of the rest of the large site?
4. Write a paragraph describing how your site compares to the area around it, as per the observations you noted in #13 above.

Extension

1. As the seasons change, the types of organisms that live in an area are likely to change as well. Predict how your area would change in a different season of the year. You will be exploring this later to see how accurate you are.
2. Describe at least two interactions between organisms on your site, or between an organism and its environment, based on your observations.
3. Based on your detailed observations and what you have learned about your site, think of a question that you could use for further investigation about your site. For example, you may want to consider

the influence of humans (for instance, traffic or maintenance) on the site; study how two species interact (perhaps a predator/prey relationship); explore the effects of physical features, such as water or sunlight, on organisms; investigate larger animal traffic through the site; or explore a specific aspect of the site through the seasons. These are just a few of many possible examples! You may want to go “micro” and explore the fine details of a rotting log on the site.

Using the tools for scientific investigation that you learned in lesson 3, write a description of how you would investigate this topic. Please give specific details! Examples of details would be your times of observation, duration, frequency, etc. Remember, your investigation must be replicable. Since you are not required to carry out this investigation, you can craft your investigation to use as long a time frame as you want.

Extra credit (optional): This project, and the subsequent visits to your site, is an introduction to phenology. If you really want to dig in and explore what this science is all about, you would need to make regular observations of a specific aspect of your site, such as a single plant and the area immediately around it, or your 2 meter x 2 meter smaller site. You will want to go out at least once a week and take notes on what you see, make sketches, and take photos from the same spot. This can be an exciting adventure, where you stick with it and continue the project throughout the year. If you choose this option, this will substitute for the revisiting of this project as explained in lessons 17 and 30. Please discuss this with your teacher for more information.

This extra credit option opens a great citizen science opportunity: Use the data you are collecting to contribute to a citizen science project! Visit *Nature's Notebook* (https://www.usanpn.org/natures_notebook) to see how you can contribute. This is a project that is creating a database of observations throughout the United States that will contribute to research, land management decisions, and policy decisions. You will see detailed instructions on how to take notes and submit your data. If you are not in the U.S., this is still a great website to learn more about phenology and tips for doing the extra credit option.

A final note

When you dismantle your string that marks your site, leave the stakes in, if possible, so when you come back to this later in the course (in lessons 17 and 30), you will know exactly where your site is. If this is not possible, take careful notes or measurements from landmarks, trees, etc. This, along with your photos, should help you find your site again.

Lesson 5: Economics and Environmental Policy

Learning Objectives

- Explain the relationship between economics and the environment.
- Relate the concept of values to environmental decision making.
- Read about the process of environmental policy in the U.S. and globally.

Reading

Read Chapter 2, Economics and Environmental Policy (35–57), in your textbook.

Some of this chapter (lesson 2, pages 42–47) discusses the structure of the United States government and U.S. environmental policy. If you are not a citizen of the U.S., you may skip that section, but you should become familiar with the structure of your government and environmental policy in your country. If you are a U.S. citizen, please read the entire chapter. No matter where you live, you may still choose project options C or D about protected lands in your country or elsewhere.

Comprehension Questions

1. Describe four assumptions of economics and “business as usual” that have traditionally had negative outcomes for the environment.

Four assumptions:

- a. Economists have often only considered internal costs and benefits, the ones that affect only the buyer and seller in a transaction. They haven’t considered outside effects, such as the effect the pollution they cause has on others.

ASSIGNMENT SUMMARY

- Read Chapter 2, Economics and Environmental Policy.
- Answer comprehension questions.
- Answer critical thinking questions.
- Choose one or more activities to complete:
 - Activity A: Ecosystem Services Value Survey
 - Activity B: Cost/Benefit Analysis
 - Activity C: U.S. Forest Service and National Park Service
 - Activity D: Protecting Land Assets

- b. Traditionally, short term costs and benefits are given much more weight than long term ones. Environmental problems usually come about in the long term.
- c. The fact that resources are not endless is sometimes not considered by economists.
- d. Lastly, the assumption that continuous growth is always required has harmful effects because it leads to overuse of resources. (39)

2. Relate the concept of the frontier ethic described in “Think About It” to the terms *anthropocentrism*, *biocentrism*, and *ecocentrism* that you learned in chapter 1 (26). Which of these terms best describes the frontier ethic?

There is no question that anthropocentrism best describes the frontier ethic! Students may go on to explain (26).

3. Cost/benefit analysis relies on assigning a monetary value to a resource or ecosystem service. Why is this often difficult?

Answers will vary, but should address the fact that it is difficult to assign a monetary value to some things, such as clean air, a beautiful landscape, or a tradition. These things can't always be quantified, and sometimes the source of a problem is hard to detect, as is the case with water and air that move long distances (38–40).

4. Which international treaty resulted in reversing the destruction of the ozone layer?

The Montreal Protocol (49, figure 10)

5. What is the role of NGOs (non-governmental organizations) in shaping policy?

NGOs contribute to environmental policy in many ways: through funding, research, education, lobbying, and protests (50).

6. Explain, using examples, why international environmental laws are needed. You may include the Tijuana River as one of your examples.

Think About It

When early European settlers came to North America, they found nothing but vast, wide-open country, occupied by relatively few native people compared to the population density where they came from. The attitude that prevailed was one of “look at all this richness, here for the taking!” The settlers quickly moved through the land, consuming its natural resources as they went. When one area became depleted, they would move westward to conquer new frontiers. This attitude is known as the *frontier ethic*, which assumes that the Earth has an unlimited supply of resources, which are there for the taking. If the resources run out in one area, more can be found elsewhere, or human ingenuity will find alternatives. It is with this perspective that North America was developed.

The frontier ethic could be linked to other places in the world as well. When the British discovered how good sugar was in tea, Britain did everything it could to increase the sugar harvest in the Caribbean. That meant exploiting slave labor to grow the cane. Largely to feed the slaves, almost every last Atlantic cod was harvested from one of the richest fisheries in the world. It was said that there were so many cod that you could walk on their backs across the Atlantic and that we could never run out! Even humans were viewed as free for the taking, to be put to use as slaves for economic gain. European countries found minerals in Africa, and exploited that continent to obtain these resources, expanding their political dominion in the process. While the focus in these examples might not have been as much on individual growth and gratification as the westward expansion in North America was, the concept is the same. The environment was exploited for human gain, and the notion that the resources were unlimited was the prevailing attitude.

Discuss this issue with your family or fellow students. What type of ethic do you feel you have? Consider the concept of entitlement. Do the people where you live take what they have for granted? If you live in a developed country such as the United States, do you feel people are evolving to have more of an environmental or sustainable ethic as compared to the frontier ethic? Or do you feel people view natural resources as free for the taking and unlimited?

You are encouraged to familiarize yourself with the topic of each Think About It section, and discuss it with your student. The goal is to help your student learn to express an opinion, support it with evidence, consider alternate viewpoints, engage in informed discussions, and respond to questions and rebuttals.

International environmental laws are needed because we are all on this one Earth together. There are many issues that involve more than one nation. Examples are rivers that carry pollution across borders (such as the Tijuana), air pollutants, animals that migrate, and even multinational companies (48).

Critical Thinking Questions

1. Answer questions 2 and 3 in the Quick Lab on page 37. Discuss this with your family or fellow students to share ideas. What would you do?

Quick Lab question 2: The table will look something like this:

| ACTIONS | COSTS | BENEFITS |
|----------------------|---|---|
| recycling the jar | wasting water (environmental and economic cost) | no plastic in the waste stream, less new plastic needs to be made |
| throwing the jar out | plastic is added to the waste stream, additional fossil fuels are used to make more plastic | water is conserved (environmental and economic benefit) |

Quick Lab question 3: Answers will vary. Examples: What happens to plastic when it is “recycled”? How much energy does that take, and how much will it cost? How much water is used to wash out the jar? How much do we pay for water?

2. When manufacturers are forced to pay a “green tax” based on the amount of environmental damage they cause, they may try to pass this cost to consumers by raising product prices. Given your understanding of the way the free market works, and considering personal responsibility, do you feel that raising prices is fair? Explain your answer.

Answers will vary, but encourage students to think about the big picture. Students may say that it is unfair because manufacturers have control over what they make, and they are the ones making the profit, so they should pay when they pollute. Encourage students to realize that in a free market system, the goal of business is to make money, and when they have a cost, they pass it on to the consumer. That’s the way business works. Manufacturers make products based on consumer demand. When the consumer buys a company’s product, they are supporting the practices of that company. When a pollution tax is passed on, it can make consumers more aware of the environmental impact of their purchases. This can encourage consumers to educate themselves, and to support the more environmentally conscious manufacturers. In this way, consumers can bring about change with their spending dollars.

3. Review comprehension question #3 in lesson 3 of this course, and your answer to it. Let’s expand on the scenario: Suppose you now know that the fish are dying because of the acidity in the water. With further investigation, it has been determined that the acidity is caused by acid rain, which is a result of sulfur dioxide being introduced into the atmosphere from coal-burning power plants hundreds of miles upwind. Which steps of the environmental policy process have already been completed? Describe the steps that need to be taken from here to solve the problem.

Steps 1 and 2 of the process have been completed. The next step is to envision a solution. After that, organizing to create a bigger voice is necessary. Then comes the “gain access” step, which involves lobbying elected officials. From there, the elected officials introduce a bill to the legislature to enact new policy. In this case, it will involve requiring coal-burning power plants to reduce sulfur dioxide emissions (53–55).

Activities

Choose one of the following activities to complete, or do more than one for extra credit.

- Activity A: Ecosystem Services Value Survey
- Activity B: Cost/Benefit Analysis
- Activity C: U.S. Forest Service and National Park Service
- Activity D: Protecting Land Assets

Students will choose one of the four projects listed. Option C is a good opportunity for U.S. students to become familiar with the public lands in their country, and how they are managed. Option D is a good opportunity for any student to learn about national parks and public lands all over the world.

Activity A: Ecosystem Services Value Survey

Consider some ecosystem services in your area that are difficult to assign a monetary value. Perhaps you live near the ocean or the mountains, where the open space and aesthetic beauty are important to you. Perhaps there is a reservoir, used for recreation as well as a water supply. Maybe there is a park nearby where people go for quiet contemplation. Maybe you have a small garden or even a window box with flowers in it that brings you and your neighbors joy.

Come up with two questions you will use to create a survey of at least five people, to determine how much they value this ecosystem service, and which values are important to them. Use some of the values in figure 4 (40) to help you craft your questions. In a third question, ask them “How much is it worth to you to keep intact the place that provides this ecosystem service? What would you pay?”

This can be done through interview or email, but please use people in your own family or community. Note that you may have to explain what “ecosystem services” means as you conduct your interviews. Prepare a report summarizing your results. Include your questions in your report.

Activity B: Cost/Benefit Analysis

Imagine that you live in a town with a coal-fired power plant nearby. Many people are employed at the power plant and at a nearby coal mine. A neighboring county is building a wind farm to generate electricity. The wind farm will be operational in a few years. The town council has raised the question of whether the existing coal power plant should be closed, as the wind farm will produce as much or more electricity. Part of the cost/benefit analysis will be considering market values as well as non-market values in order to make a wise decision. Using the following list of values, discuss how each applies to this situation by writing one or two sentences for each value. Be sure both the wind farm and the coal power plant/mine are included in your discussion. Values that are not defined in the text-book are defined here:

- economic: the gain or loss of money or jobs
- aesthetic
- environmental: the protection of natural resources
- educational
- cultural
- scientific
- health: the maintenance of human health
- ethical/moral: what is right or wrong?

Activity C: U.S. Forest Service and National Park Service

In the United States, the early 1900s brought on some policies, inspired by early conservationists, that resulted in a system of protected lands that have served as a model for the rest of the world. These systems are run by the National Park Service and U.S. Forest Service. It can be confusing to understand the difference between a national forest and a national park. Sometimes we want to lump them both together. They are very different!

Learn about these two types of land assets that belong to all the people of the United States. Research the difference between these two agencies. What kinds of protections do each provide for their lands? What uses are allowed on each? What department of the federal government oversees each agency? Write one page. Include a picture or drawing of the emblem of each agency in your report.

Activity D: Protecting Land Assets

If you live in a country other than the United States, learn about assets in your country. If you live in the U.S. and want to learn about another country of your choice, use this opportunity to do so. Research what agencies or divisions of the government exist to protect lands, promote conservation, or regulate land use. Many countries throughout the world have a national park system. Are there national parks in your country? If you live there, have you been to any of them? What is the level of protection that they provide? What kinds of uses are allowed in the parks? Are they available for anyone to enjoy? Are there new parks being proposed? Educate yourself on this topic, and write one page.