WATER CONSERVATION UNIT PLAN FOR MIDDLE-SCHOOL SCIENCE TEACHERS

By

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A capstone submitted in partial fulfillment of the requirements for the degree of Master of Arts in Education: Natural Science and Environmental Education (NSEE)

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Content Expert: Bryan Wood
Water Conservation Unit Plan

The research question guiding my capstone project is the following: to *provide lesson plans for teachers to integrate within their science curriculum to involve middle-school students in water conservation*. Drinking water is a precious resource, yet one that is taken for granted. The water conservation curriculum project produced under this research aligned with MN Science standards will provide middle school science teachers with ready-to-go lessons to teach their students to bring awareness around the importance of water. My goal in this capstone is to prepare lesson plans for middle school teachers to teach, inform and bring awareness amongst their students on topics around conservation of water.

Setting and Participants

The Water Conservation curriculum developed under this capstone can be used by any science teacher in the US in a middle-school setting and implemented any time of the year. Even though the standards that are aligned with each lesson are specific to Minnesota State, these lessons are easily adaptable by any middle school science teacher in the United States by aligning to their state standards. Studies have shown that students learn best with lessons that are hands-on. Each lesson is adapted and put together to keep student-centered inquiry in mind to achieve higher student involvement.

Curriculum Design Model

The curriculum created under this project is developed using guidelines and framework established in Understanding by Design (UbD), the model developed by Grant Wiggins and Jay McTighe. The lesson plan template that is adapted from *Understanding by Design* is tweaked a
bit to better fit all the categories for this research (see Appendix A). Backward design model has been used to design lesson plans in this project. I added MN Science Standards, Materials needed and Time required sections for an easier transition for science teachers to adapt the unit in their science classroom. The final lesson plan template can be found in Appendix A.

The unit plan is designed to be taught for ten consecutive class days during the 60-minute class period. There are three optional lessons that can be omitted from the unit plan and this unit can be taught in seven 60-minute class periods. Allow for lessons to go longer than planned as the timeline is suggested and will vary based on class sizes, student grade level, etc. The first and last lesson have built-in time for taking pre-assessment and post-assessment to measure students’ growth after teaching the unit. See Appendix C to view pre/post assessment. Detailed unit plan calendar that can be adapted to a 10-day plan or a seven-day plan can be found in Appendix B. Each lesson plan is provided in detail following the unit plan calendar in Appendix D, E, F, and G.

**Time**

The unit plan is designed to be taught for ten consecutive class days during the 60-minute class period. There are three optional lessons that can be omitted from the unit plan and this unit can be taught in seven 60-minute class periods. Allow for lessons to go longer than planned as the timeline is suggested and will vary based on class sizes, student grade level, etc. Detailed unit plan calendar that can be adapted to a 10-day plan or a seven-day plan can be found in Appendix B. Each lesson plan is provided in detail following the unit plan calendar in Appendix D, E, F, and G.
Curriculum Assessment

The goal of the Unit plan is to foster water conservation stewardship among middle school science students. In order to assess the effectiveness of the curriculum, I provided teachers with a survey to assess students’ knowledge before and after the implementation of the unit plan (see Appendix B). The pre-test will be administered before students begin learning about water and the need for conservation. The survey will help assess the difference in students’ awareness around water conservation topics before and after teaching the curriculum. At the conclusion of the unit, the teacher will administer a post-test to assess if the students understood the main point of the lesson and determine possible adaptations needed for the next time. Post-test data can also be used to compare to see if the students have mastered the benchmark outlined in the MN science standard.

The lessons included in the water unit are easily adaptable by the middle-school science teachers and implementable in their classroom in a 10-day or 7-day unit. The lesson plans are all designed with keeping higher student engagement in mind and involve hands-on activities. Students learn the best when they get to use as many senses to experience a lesson and therefore, are much more engaged. The theme that will be evident in all the lessons is water conservation but each lesson will involve different theme to emphasize importance of water. My hope is to reach as many young minds are possible to bring awareness on this critical topic and eventually it will reach the students’ family and the community members. The belief that we are all in this together and each of us can take steps at a time to make a difference that can impact water availability. With this capstone, I want to provide lesson plans for teachers to integrate within their science curriculum to involve middle-school students in water conservation.
### Appendix A
### Lesson Plan Template

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<th><strong>Lesson Format - What will students learn?</strong></th>
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<th><strong>Connection or bridge to next lesson:</strong></th>
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<th><strong>How does this lesson fit into the Unit?</strong></th>
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## Appendix B: 10-DAY UNIT CALENDAR

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<td><strong>Biodiversity</strong></td>
<td><strong>Introduction</strong></td>
<td>the world <strong>demonstration</strong></td>
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<td><strong>Finish working with Terraqua column experiment</strong></td>
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<td>(15 mins)</td>
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<td><strong>Importance of</strong></td>
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<td><strong>Conservation</strong></td>
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Appendix C:  Pre- and Post-Test

Water Conservation and Awareness Quiz

1. How much of the earth’s water is usable for drinking and farming?
   A. 10%
   B. 50%
   C. <1%

2. Where is most of the earth’s fresh water located?
   A. Reservoirs
   B. Lakes/Rivers
   C. Underground

3. How much water does a full-grown tree “give off” in 24 hours? (through the process called transpiration)
   A. 10 Gallons
   B. 40 Gallons
   C. 70 Gallons

4. How much water falls altogether when one inch of rain falls on one acre of ground?
   A. 27,000 Gallons
   B. 17,000 Gallons
   C. 7,000 Gallons

5. Who uses the most water?
   A. Farmers
   B. Industry
   C. Power Plants
   D. Individuals

6. What percentage of sewage is pure water?
   A. 30%
   B. 60%
   C. 90%

7. How much water does the average toilet flush use?
   A. 2 Gallons
   B. 5 Gallons
   C. 7 Gallons
   D. 10 Gallons

8. True or False
   Dishwashers use twice as much water as washing dishes by hand.

9. True or False
   A 10 minute bath uses 40 gallons water; a 10 minute shower uses less.

10. How much water does a leaky faucet (slow drip) waste in a day?
    A. 12 Gallons
    B. 7 Gallons
    C. 36 Gallons
    D. 48 Gallons

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Water Conservation and Awareness Quiz Answer Key (answers are in bold)

1. How much of the earth’s water is usable for drinking and farming?
   **Less than 1%**. 97.5% of water on earth is salt water. The remaining 2.5% is fresh water, mostly frozen in glaciers and ice caps.

2. Where is most of the earth’s fresh water located?
   A. Reservoirs
   B. Lakes/Rivers
   C. **Underground**

3. How much water does a full-grown tree “give off” in 24 hours? (through the process called transpiration)
   A. 10 Gallons
   B. 40 Gallons
   C. **70 Gallons**

4. How much water falls altogether when one inch of rain falls on one acre of ground?
   A. **27,000 Gallons**
   B. 17,000 Gallons
   C. 7,000 Gallons

5. Who uses the most water?
   A. **Farmers** - It takes 15,000 gallons to produce one bushel of wheat. It takes 6,000 gallons to produce one dozen eggs.
   B. Industry
   C. Power Plants
   D. Individuals

6. What percentage of sewage is pure water?
   A. 30%
   B. 60%
   C. **90% - or even 95% can be reclaimed.**

7. How much water does the average toilet flush use?
   A. 2 Gallons
   B. **5 Gallons**
   C. 7 Gallons
   D. 10 Gallons

8. True or False
   Dishwashers use twice as much water as washing dishes by hand. A modern dishwasher uses 15 gallons per wash, by hand -30 gallons.

9. True or False
   A 10 minute bath uses 40 gallons water, but a 10 minute shower will save you water. A shower uses 10 gal/min i.e.: a 100 gallons for a 10 minute shower, on average. Different kinds of shower heads will produce different results.

10. How much water does a leaky faucet (slow drip) waste in a day?
    A. 12 Gallons
    B. 7 Gallons
    C. **36 Gallons**
    D. 48 Gallons

Appendix D

Lesson Plan: Day 1, 2 & 3

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<tr>
<th><strong>Standard:</strong></th>
<th>Natural systems include a variety of organisms that interact with one another in several ways.</th>
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<tr>
<td><strong>Benchmark:</strong></td>
<td>7.4.2.1.3 Explain how the number of populations an ecosystem can support depends on the biotic resources available as well as abiotic factors such as amount of light and water, temperature range and soil composition.</td>
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**Essential Question(s)**

Why do living (biotic) and nonliving (abiotic) things need to depend on one another to thrive?

How do limiting factors affect the biotic components of an ecosystem?

**Lesson Objective:** Students will be able to:

- differentiate between biotic and abiotic factors
- understand how both, biotic and abiotic resources are needed for survival
- explore the concept of plant communities and their processes
- use the scientific processes of observation, classification, data collection, and analysis to explore life science concepts related to species diversity, as well as gain skills in characterizing the biological life of a given environment

**Materials Required:**

**S’mores limiting factor lab:** whole graham crackers, marshmallow, fun size Hershey bar, hot plate, frying pan or griddle, frying spatula, paper towel, thermal gloves, and plastic forks.

**Making Community Measurement Lab**
suitable site for study suggestions: school yard (lawn, shrubs, trees), magnifiers (one for each student is ideal), plastic bags for collecting samples, small spade or shovel, marking pens, rulers and measuring tapes, weatherproof marking tags, rope (9 meters), paper, pencils, clipboards, data sheets, field guides, ball or hula-hoop

**Biodiversity Project:** access for students to a computer lab and/or computer cart to conduct research, writing, graphic work (PowerPoint, iMovie, etc.), internet, digital cameras (optional), and arts supplies such as poster boards, permanent markers, rulers, pencils, water-based paint (tempra), paint brushes, glue, etc.

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<td>1 60-minute class period (required)</td>
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<td>2 60-minute class periods (optional)</td>
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**Prior learning activities completed before this lesson:** Students should have a clear understanding of the organizational patterns/relationships that are found in any ecosystem? (prey/predator, producers/consumers /decomposers, niche/habitat/population/community, etc.)

**Lesson Format - What will students learn?**

**Day 1: (required)**

(15 mins) **Pre-test**
(10 mins) **Biotic & Abiotic read-pair-share activity** – Students will read and answer questions individually and then pair up with a partner to discuss their answers
(30 mins) **S’mores limiting factor lab**

**Day 2: (optional)**

(50 mins) **Outdoor lab: Making community measurement**
| (10 mins) **Assign Biodiversity project as Homework** |

**Day 3: (optional)**

| (60 mins) **Biodiversity Project presentation** |

**Assessment - How will I know the students have learned?**

- Biotic and Abiotic worksheet
- S’mores Limiting factor lab questionnaire
- Making community measurement lab
- Students will complete a research project to address the impact of biotic, abiotic limiting factors on an ecosystem. A scoring guide is provided (Biodiversity Project Score Sheet.docx).

**Connection or bridge to next lesson:** Students will make connection to biotic and abiotic factors that are essential for survival. In the next lesson they will understand that water is one of the essential resources needed and can turn in to a limiting factor if we don’t take care of it.

**How does this lesson fit into the Unit?** The understanding of biotic and abiotic factors will help students categorize all the essential resources that are required for living organisms to survive. This is a broader category and eventually lead specifically to water as a resource in the following lessons.
TEKS 8.11B Dependence and Competition for biotic and abiotic factors

What is an Ecosystem?
Prairie dogs, ferrets, owls, grasses, and black-eyed Susans are all part of the same ecosystem. An ecosystem is all the organisms living together in an area along with their physical environment. A prairie is an example of an ecosystem. To meet its needs, a prairie dog must interact with more than just the other prairie dogs within its ecosystem.

Biotic Factors The parts of an ecosystem that are living, or were once living, are called biotic factors. The plants that provide food for animals in an ecosystem are biotic factors. Along with the prairie dogs in a prairie ecosystem, the ferrets and eagles that hunt them are also biotic factors. Worms and bacteria are biotic factors that live in the soil beneath the grass. As products of living organisms, prairie-dog droppings, owl pellets, and decomposing plant matter are also biotic factors. What biotic factors can you see in the ecosystem shown?

Abiotic Factors In addition to biotic factors, ecosystems consist of nonliving factors. These factors are called abiotic factors. They include sunlight, water, temperature, soil, and oxygen.

Sunlight: Because sunlight is needed for plants to make their own food, it is an important abiotic factor for most living things. There are very few ecosystems that do not include sunlight as a key abiotic factor.

Water: Every living thing requires water to carry out life processes. Plants and algae need water along with sunlight and carbon dioxide to make their own food. Animals need water to carry out processes inside their cells.

Temperature Range: The typical temperature range in an area determines the types of organisms that can live there. Most organisms can survive only if their body temperatures stay within a certain temperature range.

Soil Composition: Soil consists of rock fragments, nutrients, air, water, and the decaying remains of living things. The soil in an area influences the kinds of plants and animals that can live and grow there.

Oxygen: Most living things require oxygen to carry out their life processes. Organisms on land obtain oxygen from the air. Aquatic organisms obtain oxygen that is dissolved in the water around them.

Organisms and Populations An organism is an individual living thing. For example, you are an organism, a prairie dog is an organism, and a black-eyed Susan is an organism. Every organism is a member of a species, a group of similar organisms that mate with each other and reproduce. A population is all the members of the same species that live in the same area at the same time. For example, all of the prairie dogs that live in one area of underground burrows make up one population.
How do organisms depend on biotic factors?
All animals depend on other organisms for food. For example, in a prairie, grasses and seeds provide the food for prairie dogs. In turn, prairie dogs are food for eagles and ferrets. Worms depend on the remains of decaying organisms for their energy. Organisms require enough food to survive. Suppose a giraffe must eat 10 kilograms of leaves each day to survive. If the trees in an area can provide giraffes 100 kilograms of leaves a day while remaining healthy, the trees could easily support a population of five giraffes. A population of 15 giraffes could not thrive in the area—there would not be enough food. No matter how much water and other resources were also there, the population would not be likely to grow much larger than 10 giraffes.
Some organisms depend on other organisms for shelter. For example, many birds build nests in trees from broken twigs and other plant debris. Some plants grow upon another plant rather than growing in soil.

How do organisms depend on abiotic factors?
Abiotic factors are also very important to all living things. Plants cannot grow without sunlight, water, and soil. Animals need water and energy from sunlight to provide the proper temperature range.

Sunlight: Every organism requires energy. Sunlight provides the light energy plants need for photosynthesis. During photosynthesis, plants convert light energy into chemical energy stored in food molecules. If taller plants shade the grasses in a prairie from sunlight, the grasses cannot get enough sunlight to produce the food they need to live. Over time, the taller plants may replace the grasses.

Water: Organisms also require water to survive. Environments that have plenty of water usually support a larger number and variety of organisms than environments with less water. Many thousands of species can live in a tropical rain forest. Only those species that can survive for long periods without water can survive in a desert.

Temperature range: In addition to the light that plants use to grow, sunlight provides Earth with thermal energy. The movement of thermal energy is called heat. Temperature plays a major role in determining whether specific organisms can survive in a particular environment. Polar bears have adapted to survive the freezing temperatures of the Arctic. Meerkats live in the extreme heat of the Kalahari Desert. Neither of these animals can survive in the other’s ecosystem.

Soil Composition: Soil is an abiotic factor because it consists mostly of nonliving rock and mineral particles. However, soil also contains living organisms and decaying matter. The type of soil present in an ecosystem has a major effect on the types of plants that can grow there. Soil provides the nutrients plants need, as well as support for the plants' roots.

How do organisms compete for biotic and abiotic factors?
Prairie dogs feed on grasses, seeds, and roots. They sleep in underground burrows. As the population of prairie dogs increases, more food and more burrows are needed. Eventually, the supply of both biotic and abiotic factors necessary for life may fall short of the demand for them.

Competition Members of the same population use the same resources in the same way. Some resources, such as food and water, may be limited in an area. So, after a time, the members will begin to compete with each other for resources. The struggle among organisms to survive as
they attempt to use the same limited resources is called **competition**. Competition can also occur between different organisms. For example, weeds in a garden compete with vegetable crops for soil nutrients, water, and sunlight.

In any ecosystem, there are limited resources. Organisms that share the same ecosystem often have adaptations that enable them to reduce competition. For example, the three species of warblers shown below each specialize in feeding only in a certain part of the spruce tree. Because they do not directly compete, one warbler does not reduce the resources available to a warbler of a different species.
**TEKS 8.11B Dependence and Competition for biotic and abiotic factors**

1. What kind of factor is sunlight in an ecosystem? __________________
2. Which of these environmental factors is a biotic factor of an ecosystem?
   A water  B sunlight  C food  D soil
3. How are biotic factors similar to abiotic factors? How are they different?
   ______________________________________________________________________________
4. List 3 organisms that depend on biotic factors? ________________________________
   ______________________________________________________________________________
5. Why is soil an abiotic factor? _________________________________________________
   ______________________________________________________________________________
6. Name the abiotic factors that can affect organisms in an environment.
   ______________________________________________________________________________
7. Which factor in a forest ecosystem is a biotic factor?
   A temperature  B water  C soil  D maple trees
8. What is the abiotic factor that provides the energy used by organisms in almost every ecosystem on Earth?
   A sunlight  B food  C fossil fuels  D oxygen
9. What is the difference between an organism and a population?
   ______________________________________________________________________________
10. Define ecosystem in your own words. __________________________________________
    ______________________________________________________________________________
11. Why does competition happen in an ecosystem?
    A abundant abiotic factors  B limited resources
    C different temperature ranges  D different resources usage
12. What would happen if all three warbler species fed in the same location on the tree?
    ______________________________________________________________________________
    ______________________________________________________________________________
13. What might happen to the other two warbler species if you removed the third warbler species from spruce trees?
    ______________________________________________________________________________
    ______________________________________________________________________________
14. What might cause two organisms of different species to compete with one another in an ecosystem?
    ______________________________________________________________________________
    ______________________________________________________________________________
15. Being able to compete successfully for space is important to plants because they cannot move to a new place if their ecosystem becomes too crowded. The roots of a sorghum plant produce a chemical that suppresses the growth of other species of plants. How might this chemical be useful for gardeners?
    ______________________________________________________________________________
    ______________________________________________________________________________
Biotic, abiotic. Alive or not?

This document was generated on CPALMS - www.cpalms.org

The purpose of this lesson is to introduce students to the concept of biotic & abiotic factors, the elements that define an ecosystems, and how these become limiting factors in an ecosystem. The teacher will have a variety of teaching strategies to review the students' prior knowledge of their understanding of the organizational patterns and relationships that are found in any ecosystem. In addition, the teacher will combine different teaching methods (technology/multimedia/internet, art, laboratory experiment, note writing strategy, self formative assessment) to introduce and deliver the main topic of this lesson.

Subject(s): Science
Grade Level(s): 7
Intended Audience: Educators
Suggested Technology: Computer for Presenter, Computers for Students, Internet Connection, Basic Calculators, LCD Projector, Microsoft Office

Instructional Time: 2 Hour(s)
Resource supports reading in content area: Yes
Freely Available: Yes
Keywords: biotic, abiotic, predator, prey, ecology, limiting factors, consumers, producers, decomposers,
Instructional Component Type(s): Lesson Plan
Resource Collection: FCR-STEMLearn Diversity and Ecology

ATTACHMENTS
Exit Slip.docx
Biodiversity Project Score Sheet.docx
Cornell Style Notes.pptx
Smores Limiting Factor Lab.doc

LESSON CONTENT

- Lesson Plan Template:

  General Lesson Plan

- Learning Objectives: What should students know and be able to do as a result of this lesson?
Students will be able to identify and compare biotic and abiotic factors.

Students will be able to identify and analyze how limiting biotic and abiotic factors impact native population in their local ecosystem.

- Prior Knowledge: What prior knowledge should students have for this lesson?

Students should have a clear understanding of the organizational patterns/relationships that are found in any ecosystem? (prey/predator, producers/consumers /decomposers, niche/habitat/population/community, etc.)

The teacher can assess initial student understanding by asking:

- What does biotic mean? (Living entities such as animals, plants, bacteria, etc.)
- What does abiotic mean? (Non-living entities such as water, sunlight, air, temperature, minerals, etc.)

- Guiding Questions: What are the guiding questions for this lesson?

How do the biotic and abiotic components of an ecosystem interact? (Example: ecological processes such as decomposition, shelter, respiration, photosynthesis)

How do limiting factors affect the biotic components of an ecosystem? (Example: the availability of food, water, nutrient, shelter, and predation pressure can limit population size.)

- Teaching Phase: How will the teacher present the concept or skill to students?

Phase A. Assessing for Prior Knowledge

The teacher will set up pictures around the classroom of the various elements present in an ecosystem (prey/predator, producers/consumers /decomposers, niche/habitat/population/community, etc.). The pictures will be labeled with letters so students can match them with the words on their index cards.

As students walk around the classroom, the teacher will hand them an index card with words describing the elements of an ecosystem.

The teacher will begin the lesson by forming groups of 3-4 students.

The teacher will direct students to walk around the classroom to observe the pictures on the wall and match the photo with the words written on their index card. Students will have 5-10 minutes to complete this task.

After students complete their gallery walk, they will report their findings to the class and they will explain their reason for their choice. As the students make their presentation, the teacher will be rating them for accuracy using the following rubric:
1=they don't get it, 2=the sort of get it but need further help 3= they get it but can not teach it to others, 4=they totally get it and can teach it to others.

Phase B. Teaching the lesson

The teacher will show a PowerPoint show: (http://betterlesson.com/community/document/122468/checking-for-understanding-biotic-and-abiotic) of photos of living and nonliving things (i.e. a bird, water fall, sunlight, a gold ring, a cat, etc.). The teacher will ask students to write down on a sheet of paper which of the pictures are representations of living and nonliving thing.

The teacher will review the answers to this activity with students, then she/he will ask students to identify the difference between the two groups (living things require food & shelter for survival, reproduction to preserve the species, they develop, grow and die).

After a brief discussion, the teacher will ask students to raise their cards indicating level of understanding (1=I don't get it, 2=I sort of get it but need further help 3= I get it but can not teach it to others, 4=I totally get it and can teach it to others). The teacher will group students with low level of understanding with those with high level of understanding for a brief peer tutoring session.

Explanation of the Concept:

The teacher will show a video (I suggest the following links: http://www.youtube.com/watch?v=_gUfdsuOmpE, http://www.youtube.com/watch?v=MdlwPtKg-VI) containing living and nonliving thing and she/he will explain how these biotic and abiotic factors can limit the type of population and quality of life in an ecosystem.

After a brief discussion of the video, the teacher will assess student's mastering of the concept using the worksheet found on the following link: http://www2.ccsd.ws/sbfaculty/team8e/jecole/Science/abiotic_vs_.htm

- Guided Practice: What activities or exercises will the students complete with teacher guidance?

Lab Activity: See the attached S'mores Limiting Factor Lab.

The tips below are intended to assist the teacher to conduct a successful and safe lab.

Time needed: 30-40 min; 10 minutes to give instructions and 20-30 minutes for the students to make their s'mores and respond to the questions.

Description: Students will relate the making of s'mores to biotic and abiotic as limiting factors in an ecosystem.
Safety Considerations: Make sure students exercise caution when working with heat and electricity. Wear thermal gloves to prevent burning!

Clean up time: Make sure you allow 5-10 minutes at the end of the lab for students to clean up.

Procedure: Pass out the Smore Limiting Factor Lab worksheet to each student and read the instructions aloud as they follow along. (The more dramatic the better) Explain to each group that they will obtain the necessary materials to perform the lab but they must first review the concept of limiting factors in order to identify which ingredient represent the limiting factor.

• Independent Practice: What activities or exercises will students complete to reinforce the concepts and skills developed in the lesson?

Students will work in small groups to produce a biodiversity project that will include research and reporting of their topic, diagrams, a multimedia presentation, and a class presentation. Details are provided on the Biodiversity Project Score Sheet.docx (attached) and the point value of each section is included in parenthesis. This project will serve as this lesson's summative assessment.

The teacher will review the main ideas of this project with students to ensure that they have mastered the concepts biotic, abiotic, and limiting factors. Students will demonstrate the new knowledge by producing a research project that connects these concepts with "real life" practical applications to address this lesson's objectives.

The research project must demonstrate how bioitic and abiotic factors play a role in limiting population growth in an ecosystem. For instance, the introduction of the Australian maleluca tree to South Florida as an ornamental plant displaced many native species their natural environment.

Students will use the outline attached to complete this project.

• Closure: How will the teacher assist students in organizing the knowledge gained in the lesson?

In order to organize, store and review the material covered in this lesson, students can utilize a note writing strategy of your choice. An example is given of "Cornell Notes" in the attached PowerPoint file. This tool will help students summarize the main idea or topic by answering guiding questions, define vocabulary, and provide examples of the concept discussed in a well structure format.

The teacher may choose to close this lesson using the "Exit Slip" attached:
The teacher may also revisit these questions:
1. What does biotic mean? (Non-living entities of an ecosystem such as water, sunlight, air, temperature, minerals, etc.)

2. What does abiotic means? (Living entities of an ecosystem such as animals, plants, bacteria, etc.)

3. What are the biotic and abiotic components of an ecosystem? (Biotic components include all living organisms; abiotic components include water, rock/soil/minerals, air, light, energy)

4. What are limiting factors? (The availability of food, water, nutrient, shelter, and predation pressure are examples of factors limiting the growth of a population size.)

Summative Assessment

Students will complete a research project to address the impact of biotic, abiotic limiting factors on an ecosystem. A scoring guide is provided (Biodiversity Project Score Sheet.docx).

An exit slip is provided that could be used as a formative assessment summative assessment.

- **Formative Assessment**

An informational assessment opportunity is provided within the lesson plan. Students will hold up one of four cards illustrating the degree of their understanding as indicated by the number on their cards (1=I don't get it, 2=I sort of get it but need further help 3= I get it but can not teach it to others, 4=I totally get it and can teach it to others) when prompted by their teacher.

A worksheet activity part way through the lesson provides another opportunity to assess student understanding.

- **Feedback to Students**

Students can be grouped according to their level of understanding as demonstrated by the card they held up and the teachers will circulate among the groups to provide further explanation of the concept discussed.

Students who have demonstrated a high level of understanding, as demonstrated by the card they held up when prompted by their teacher, will be grouped with students who need further assistance understanding the lesson (students holding up cards number 1, 2, and 3) for peer tutoring.
ACCOMMODATIONS & RECOMMENDATIONS

- Accommodations:

  This lesson plan is flexible and easily can be adjusted:

  - provide verbal encouragement
  - form heterogeneous group of students which include students with special needs, ELL students and high performing without disabilities and proficient in the English language.
  - allow extra time for the completion of projects, labs and, and test.

- Special Materials Needed:

  - Pictures of abiotic and biotic factors to hang up around the room.
  - Smores limiting factor lab: whole graham crackers, marshmallow, fun size Hershey bar, hot plate, frying pan or griddle, frying spatula, paper towel, thermal gloves, and plastic forks.
  - Biodiversity Project: access for students to a computer lab and/or computer cart to conduct research, writing, graphic work (PowerPoint, iMovie, etc.), internet, digital cameras (optional), and arts supplies such poster boards, permanent markers, rulers, pencils, water-based paint (tempra), paint brushes, glue, etc.
  - Rating my Understanding: index cards for each student

- Further Recommendations:

  It is highly recommended that the teacher secure all the materials necessary for the activities listed under "Activity" in the previous section at least 24 hours in advance. It is also recommended that the teacher perform the Smore's lab on their own at least 24 hours before students attempt this activity.

  Furthermore, the teachers should review the process of writing class notes using the "Cornell Notes" strategy, using the attached powerpoint, before assigning this activity to students.

  The teacher will set up a schedule that highlight dates when certain sections of the Biodiversity project should be completed in order to monitor students' progress.

SOURCE AND ACCESS INFORMATION

**Contributed by:** Melvin Figueroa Mateo

**Name of Author/Source:** Melvin Figueroa Mateo

**District/Organization of Contributor(s):** Broward

**Is this Resource freely Available?** Yes
Title: S’mores lab

Objective: To relate the making of s’mores to biotic and abiotic as limiting factors in an ecosystem.

Materials Needed: Each student will need: whole graham crackers, marshmallow, fun size Hershey bar. You will also need a hot plate, frying pan or griddle, frying spatula, paper towel, thermal gloves, and plastic forks.

Procedure:
1. Connect the hot plate and set its temperature to high. Place the frying pan or griddle on the hot plate.
2. Split graham cracker into 2 halves. On top of graham cracker squares place mini-marshmallows.
3. Place cracker and marshmallow on a hot frying pan or griddle for a few seconds until toasty.
4. Remove and place 1/2 of a Hershey bar on top of marshmallow. The heat from the marshmallow will melt the chocolate bar.
5. Place other 1/2 of graham cracker on top. Press lightly to flatten marshmallows.
6. Remove smore from frying device; be careful not to burn yourself.

Analysis:
1. Given 18 squares of chocolate, how many s’mores can you make if the other ingredients are in excess?

2. If you wished to make 3.5 S’mores, how many graham cracker halves would be needed?

3. Given 7 graham cracker halves, 2 marshmallows and 20 squares of chocolate:
   (a) What is the limiting ingredient?
   (b) What is the theoretical yield of s’mores?

4. While doing the experiment described in question 3 above some sugar-starved runner eats some of your ingredients and you are only able to make 2 s’mores. What is your percent yield?
Making Community Measurements: Biotic Factors

10. Introduction

In this lesson, students will identify a local plant community and make a variety of measurements, preferably during two different seasons. Students will identify an individual organism, a species, and a population within the study community. Next, students will identify biotic factors at the site and attempt to characterize the site’s species diversity. Finally, they will characterize the community as a whole based on their measurements.

2 Objectives

A This series of activities enables students to explore the concept of plant communities and their processes.

B Students will use the scientific processes of observation, classification, data collection, and analysis to explore life science concepts related to species diversity, as well as gain skills in characterizing the biological life of a given environment.

11. Standards Assessed

Grades 3–5

Life Sciences
Science Content Standards K–12 (2000), California State Board of Education
10. Ecosystems can be characterized by their living and nonliving components (4-3.a).
Grades 3–5 (cont.)

Investigation and Experimentation

*Science Content Standards K–12* (2000), California State Board of Education

2 Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept . . . students should develop their own questions and perform investigations (3–5, 4–6, 5–6).

Grades 6–8

*Life Sciences*

*Science Content Standards K–12* (2000), California State Board of Education

11. The number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors such as quantities of light and water, a range of temperatures, and soil composition (6–5.e).

Investigation and Experimentation

*Science Content Standards K–12* (2000), California State Board of Education

♦ Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept . . . students should develop their own questions and perform investigations (6-7, 7-7, 8-9).

The Living Environment

*Benchmarks for Science Literacy* (1993), American Association for the Advancement of Science

♦ In all environments—freshwater, marine, forest, desert, grassland, mountain, and others—organisms with similar needs may compete with one another for recourses, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depend on the physical conditions (5.D 6-8).

IV. Background

While at the Huntington Botanical Gardens, your class will visit three different gardens: the Desert Garden, Lily Ponds, and the Jungle Garden. Each of these gardens represents a distinct plant community in which plants exhibit adaptations to the unique conditions of their local environment.

A community is made up of plant and animal populations living together in a common environment and interacting with each other. Environment includes all the living (biotic) and nonliving (abiotic) aspects. Differing plant communities have unique biological, chemical, and physical characteristics. Abiotic factors that govern plant community distribution include climate, geology and soils, shade/sunlight conditions, topographic position, elevation, latitude, and others. Biotic factors include the associated plants, animals, fungi, and microorganisms, and their interactions.
Within each community, there are many **habitats** for given organisms. These habitats range in size considerably, depending on the species and the size of its local population. A **population** is comprised of members of the same species living in the same place at the same time. A **species** is a group of organisms that are able to breed together and produce offspring that can also breed with members of the same species.

In addition, plants can be characterized by their form (or habit). Woody plants produce growth both upwards (growth from the stem tips) and outwards (increase in circumference by producing growth in rings) and include trees and shrubs. In general, **trees** have one main trunk and are over 20 feet high at maturity. **Shrubs** often have several to many main trunks and are less than 20 feet in height at maturity. **Herbaceous** plants are non-woody and include those with conspicuous flowers as well as those with inconspicuous flowers. Herbaceous plants with conspicuous flowers often have showy petals or other parts, and encompass a broad range of plants from poppies to buttercups to primroses. Herbaceous plants with inconspicuous flowers include grasses, sedges, rushes, and others. **Grasses** are very common in schoolyards and have leaves with parallel veins, jointed stems, slender sheathing leaves, and inconspicuous green flowers with unique arrangements of parts.

**V. Materials Needed**

- suitable site for study
  - suggestions:
    - school yard (lawn, shrubs, trees)
    - community garden
    - park
    - field
    - natural plant community
- magnifiers (one for each student is ideal)
- plastic bags for collecting samples
- small spade or shovel
- marking pens
- rulers and measuring tapes
- weatherproof marking tags
- rope (9 meters)
- paper
- pencils
- clipboards
- data sheets (see below)
- field guides
- ball or hula-hoop
VI. Procedure

Guide students through a discussion of plant communities, habitats, populations, species, and individual organisms. Introduce the concepts of biotic and abiotic factors. Explain that they will be visiting a site and making community measurements. (If the site is the schoolyard lawn, it can be called the schoolyard community.)

Students can work in teams to make a variety of measurements (see also data sheet at end). To ensure that measurements are a good characterization of the site as a whole, you can employ a couple of techniques. One is to create a grid using a measuring tape and assign students in incremental units to take measurements at a given site. The other technique is a random method: give students a hula-hoop and have them toss them from the perimeter of the site. Wherever it lands, that is where they make the measurements.

1. Ask students to work in groups in their study area to find examples of the following:
   a. an individual plant
   b. a population of the same plant
   c. two different species of plants
   d. an individual animal
   e. a population of the same animal
   f. a plant habitat
   g. an animal habitat (ants, earthworms, birds, etc.)

2. Biotic characteristics of the site can be recorded in a variety of ways:
   a. One pair (or more) of students should be assigned to record the number of different kinds of living things they observe at the site. A complete checklist can be compiled. Unknown plants can be called Unknown plant #1, Unknown plant #2, etc. Back in the classroom, students can be introduced to field guides to aid in identification. A summary can be prepared that includes the number of plant types (species) with different forms (habits) such as trees, shrubs, grasses, non-woody flowering plants, along with animals such as insects, birds, etc. This can easily be tied into a unit on classification of living things.

   b. Introduce the term “diversity.” Diversity means variety, and in the context of species diversity within a plant community, it refers to the number of different types of plants and animals (species). It can also refer to the diversity of habitats as well. We will examine plant species diversity at the study site.

3. Students can be introduced to plot sampling. Explain that the goal is to measure the number of different plants in a plot, as well as their abundance. Abundance can be measured by number of individuals or by area covered.
   a. Divide students into teams of 4.
b. Pick a spot in the schoolyard. Each team should throw a ball out into the yard (over your head backwards might be a good way to go to ensure randomness).

c. After the ball has landed and is stationary, place the rope in a circle around the ball, laying it on the ground, on top of the vegetation.

d. Have students record the number of different plant species in each plot, along with an estimate of coverage by each species.

4. Summarize all data and ask each group to prepare a presentation to the class that describes the study community.

VII. Discussion Questions

1. How would you characterize the community you are studying? Do trees, shrubs, or grasses dominate the area?

2. How many individuals did you observe in your study site? How many populations? Species?

3. Would you characterize this site as being rich in species or poor in species? Why?

4. What plant community in the wild do you think your study site resembles? Do you think species diversity between the two communities is similar?

5. Which community (your site or the similar natural community) would most easily be disrupted by disease or pests? Why?

6. Why is diversity important? (In general the higher the species diversity at a site, the more complex the food chains and webs. Further, genetic diversity is important in species survival; the more diverse populations tend to contain some individuals with characteristics that may be essential in survival if there are changes in the environment.)

When returning for second investigation in a different season:

1. Compare the same plants between the two seasons. What changes are observed?

2. What things are the same about this community during the two seasons? What things are different?

VIII. Discussion Questions Related to Reading Plants

After your visit to the Huntington Botanical Gardens, explore the following questions:

1. What plant forms dominate in the Jungle Garden? (Woody plants, trees and shrubs, as well as vines.) Why do you think this is?

2. What plant forms dominate in the Desert Garden? (Low-growing shrubs, few
trees, herbaceous plants, include succulent cacti and euphorbia.) Why do you think this is?

3. What plant forms dominate in Lily Pond Garden? (Some trees by edge of pond, many herbaceous plants such as sedges including Papyrus, rushes, grasses, cattails, and water-lilies, and others.) Why do you think this is?

4. Which of these environments has the greatest species diversity?

IX. Extension Activities and Web Links

Ask students to repeat this exercise in some area near home as a special project.

Have students make a plant collection, pressing specimens, and labeling them.

Ask students to research some natural communities in the wild that are similar to their study site and compare results—the dominant plant form in the communities (trees, shrubs, grasses, etc.), species diversity, rare taxa, etc.

Compare results of research on three communities studied at the Huntington (freshwater aquatic habitats, deserts, and tropical rain forests) with your study site.

Living Things: Units of Study (Franklin Institute of Science)
Nice synopsis of community ecology terms with links to other lessons.
<http://www.fi.edu/tfi/units/life/life.html>

Food Chains: How the World Works (BrainPOP)
Kid-friendly animations and information about science, health, & technology.
<http://www.brainpop.com/science/ecology/foodchains>

Growth and Development: Wisconsin Fast Plants (University of Wisconsin)
Germination experiments using Fast Plants.
<http://www.fastplants.org/resources/lifecycle/growth_development.html>
## Vocabulary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>abiotic</td>
<td>nonliving, as opposed to biological or biotic</td>
</tr>
<tr>
<td>biotic</td>
<td>relating to life; the living components of an environment</td>
</tr>
<tr>
<td>community</td>
<td>all the organisms living together in a common environment and interacting with one another</td>
</tr>
<tr>
<td>diversity</td>
<td>variety; the number of different species of plants and animals or types of habitats</td>
</tr>
<tr>
<td>environment</td>
<td>conditions; all the conditions around a plant or an animal, such as amount of space in which to live, climate, other plants and animals, etc.</td>
</tr>
<tr>
<td>grass</td>
<td>an herbaceous plant with parallel veins, jointed stems, slender sheathing leaves, and inconspicuous green flowers</td>
</tr>
<tr>
<td>habitat</td>
<td>the natural area in which an individual, species, or population lives</td>
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<tr>
<td>herbaceous</td>
<td>non-woody plants which do not grow outwards, may or may not produce conspicuous flowers</td>
</tr>
<tr>
<td>population</td>
<td>members of the same species living in the same place at the same time</td>
</tr>
<tr>
<td>shrub</td>
<td>multibranched plant which remains under 20 feet in height at maturity</td>
</tr>
<tr>
<td>species</td>
<td>a group of organisms that are able to breed together and produce offspring that can also breed with members of the same species</td>
</tr>
<tr>
<td>tree</td>
<td>woody plant, usually with one main trunk, which reaches more than 20 feet in height at maturity</td>
</tr>
<tr>
<td>woody</td>
<td>plants which grow outwards, increasing in circumference</td>
</tr>
</tbody>
</table>
### Making Community Measurements: Biotic Factors

Names: ___________________________ Date: ____________

Location: ________________________

Count each different type of plant in the circle. If you know its name, write it in the left-hand column. If you don’t know its name, give it a number. Try to estimate how many of each type of plant you find.

<table>
<thead>
<tr>
<th>Name of plant</th>
<th>Amount or number found</th>
<th>Description of plant (form or habit, indicate if flowering, fruiting, etc.)</th>
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</tbody>
</table>
Describe the appearance of three common plants in this habitat.

<table>
<thead>
<tr>
<th><strong>Plant 1</strong> (name, if known):</th>
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<tbody>
<tr>
<td>Height:</td>
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<tr>
<td>Width:</td>
</tr>
<tr>
<td>Leaves (size, color, shape):</td>
</tr>
<tr>
<td>Flowers:</td>
</tr>
<tr>
<td>Fruits:</td>
</tr>
</tbody>
</table>

Make a drawing of the profile of this plant:

Make a drawing of a small branch of this plant, including leaves and stems:

<table>
<thead>
<tr>
<th><strong>Plant 2</strong> (name, if known):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height:</td>
</tr>
<tr>
<td>Width:</td>
</tr>
<tr>
<td>Leaves (size, color, shape):</td>
</tr>
<tr>
<td>Flowers:</td>
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<tr>
<td>Fruits:</td>
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</tbody>
</table>

Make a drawing of the profile of this plant:

Make a drawing of a small branch of this plant, including leaves and stems:
<table>
<thead>
<tr>
<th><strong>Plant 3</strong> (name, if known):</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Height:</strong></td>
</tr>
<tr>
<td><strong>Width:</strong></td>
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<tr>
<td><strong>Leaves</strong></td>
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<tr>
<td><em>(size, color, shape):</em></td>
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<tr>
<td><strong>Flowers:</strong></td>
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<tr>
<td><strong>Fruits:</strong></td>
</tr>
</tbody>
</table>
Biodiversity Project-score sheet

A) The Effect of Invasive Species on the growth of native species (50 points)

1. Identification of Invasive Species – select an animal or plant which is not originally from an ecosystem in Florida

2. Florida Ecosystem (i.e. coral reef, Everglades, scrub, etc.)
   a) Importance of biotic (living) & abiotic (nonliving) factors to the ecosystem- explain how the biotic and abiotic factors help maintain the balance in the ecosystem.
   b) Compatibility of geographic location & climate – describe how the climate and geographical location of the ecosystem you are studying are conducive for native species thrive.
   c) Source of nutrients – identify the source of food in the ecosystem you are studying which sustain the native species of animals and/or plants which may be affected by an introduction of an invasive species.

3. Place on the food web – What is the role of the native you species you have selected to study in their ecosystem?
   a) Predator/prey-identify the role of your specie and its enemies
   b) Producer-Plants, green algae, phytoplankton
   c) Primary Consumer
   d) Secondary Consumer
   e) Decomposer

B) Identity how the introduction of an invasive species disturbs the ecosystem you are studying (50 points)

1. Method or mechanism of invasion-how did the invasive species (IS) ended up in their new ecosystem?

2) Mechanism of damage to the IS’s “new” ecosystem-how does the IS causes damage to their new area?
   a) Voracious feeding
   b) Lack of enemies/predator
   c) Fast reproduction
   d) Effective defense & adaptability

3. Explain how the native Species (NS) is affected by the introduction of an invasive species (IS).
   a) Name the NS
   b) Identify and explain how both species (NS & IS) compete for the resources in their ecosystem.
   c) What is the limiting resource?
   d) Explain the management system developed to protect the NS and its environment.
C) Art/Digital media showcase (50 points)
   1. Poster
   2. Power Point
   3. iMovie
   4. Photo collage
   5. Newspaper/magazine Journal

D) Class Presentation (50 points)
## Appendix E

### Lesson Plan: Day 4 & 5

<table>
<thead>
<tr>
<th><strong>Standard:</strong></th>
<th>Water, which covers the majority of the Earth’s surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benchmark:</strong></td>
<td>8.3.2.3.1 Describe the location, composition and use of major water reservoirs on the Earth, and the transfer of water among them.</td>
</tr>
<tr>
<td><strong>Essential Question(s):</strong></td>
<td>How does the water cycle affect the amount of freshwater that’s available for living beings to use?</td>
</tr>
</tbody>
</table>
| **Lesson Objective:** | Student will be able to  
  - understand how sun helps with the water cycle  
  - explain phenomena of water cycle and the terms associated with it  
  - where the water stays the most in the water cycle  
  - explain how much freshwater water is available for human use |
| **Materials Required:** |  
  **Water cycle introduction:** access to internet  
  **Incredible journey** – 9 large pieces of paper, copies of water cycle table, marking pens, 9 boxes about 6 inches on a side, copies of cube pattern  
  **All the water in the world:** 1-L container (soda bottle), 100-mL graduated cylinder, eyedropper, ice cube tray, small container, salt, drawing paper, colored markers  
  **Water, Water Everywhere:** 7 clear containers (2 one-liter, 5 smaller), 1 plate, overhead projector, masking tape, marking pen, 1 liter water, salt, sand (250g), blue food coloring, one eye dropper, graph paper, calculators, copies of student worksheet, freezer |
**Water footprint calculator:** students with access to internet, copies of reading.

**Time Required:**
2 60-minute class periods

**Prior learning activities completed before this lesson:**
Biotic & Abiotic read-pair-share activity, S’mores limiting factor lab, Outdoor lab: Making community measurement and Biodiversity project

**Lesson Format - What will students learn?**

**Day 4**

(5 mins) **Water cycle Introduction** - Introduce the lesson with the following Water Cycle Rap [https://www.youtube.com/watch?v=KM-59IJA4Bs](https://www.youtube.com/watch?v=KM-59IJA4Bs)

(55 mins) **Incredible Journey activity**

**Day 5**

(20 mins) **All the water in the world**
(20 mins) **Water, Water Everywhere** – students observe a brief demonstration on the distribution of the world’s water and then calculate how much water they use on a daily basis, both directly and indirectly.

(20 mins) **My water footprint** – Work on it in class and assign the rest as homework

**Assessment - How will I know the students have learned?**

- Class discussion after water cycle rap video
- Incredible journey activity sheet
- All the water in the world result discussion
- Water, Water Everywhere student questionnaire worksheet
- My water footprint calculator 3-step assignment

**Connection or bridge to next lesson:** Students will understand that water is one of the essential resources needed and can turn in to a limiting factor if we don’t take care of it. Water cycle doesn’t always put freshwater in the right places where it’s needed. In the next lesson,
students will make connection that sun is the ultimate source of energy and controls many processes in nature.

**How does this lesson fit into the Unit?** The understanding of water cycle in this lesson will help students see how water is transferred from one form to another in nature. In addition, students will realize that freshwater is a finite resource and we must take care of it to conserve it.
The Incredible Journey

Where will the water you drink this morning be tomorrow?

**Project Summary**

With a roll of a cube, students simulate the movement of water within the water cycle.

**Objectives**

Students will:
- describe the movement of water within the water cycle.
- identify the states of water as it moves through the water cycle.

**Materials**
- 9 large pieces of paper
- Copies of Water Cycle Table (optional)
- Marking pens
- 9 boxes, about 6 inches (15 cm) on a side
- Copies of Cube Pattern

Boxes are used to make cubes for the game. Gift boxes used for coffee mugs are a good size or inquire at your local mailing outlet. There will be one cube (or box) per station of the water cycle. To increase the pace of the game, use more boxes at each station, especially at the clouds and ocean stations.

The labels for the sides of the cubes are located in the Water Cycle Table. These labels represent the options for pathways that water can follow. Explanations for the labels are provided. For younger students, use pictures.

Another option is to make a spinner for each station using sturdy cardboard, as shown in the illustration.

- Pipe cleaner, thin elastic, leather or similar item for making bracelets (one per student)
- Plastic beads or any similar objects in yellow and nine other colors to thread onto the bracelet
- Copies of Water Journey Map (one per student)
- Pencils
- A bell, whistle, buzzer or some soundmaker

---

**Vocabulary**

condensation, evaporation, electromagnetic energy, precipitation, melt, freeze, water cycle, molecule, heat energy, solid, liquid, gas, perspiration, gravity, dew, respiration, digestion, transpiration, sublimation, deposition

---

*If cubes are unavailable, a spinner may be made for each station.*
Make Connections
When students think of the water cycle, they might entertain the misconception that a circle of water flows from a stream to an ocean, evaporates into the clouds, rains down on a mountaintop and flows back into a stream. The movement of water is much more dynamic than that. It is truly a cycle: water is ever-moving, with no beginning or end. By role-playing a water molecule, students learn to conceptualize the water cycle in a way that more closely approximates how water actually travels.

Background
While water does circulate from one point or state to another in the water cycle, the paths it can take are variable.

Heat energy directly influences the rate of motion of water molecules. When the motion of the molecule increases because of an increase in heat energy, water will change from solid to liquid to gas. It is possible for water to go directly from a solid to a gas through a process called sublimation; under the right circumstances, snow and ice can change into water vapor without first melting into water. The opposite of sublimation is deposition, from which water vapor changes directly into ice—such as snowflakes and frost. With each change in state, physical movement from one location to another usually follows. Glaciers melt to pools, which overflow to streams, from which water may evaporate into the atmosphere.

Gravity further influences the movement of water over, under and above Earth's surface. Water as a solid, liquid or gas has mass and is subject to gravitational force. Snow on mountaintops melts and descends through watersheds to the oceans of the world.

One of the most visible states in which water moves is the liquid form. Water is seen flowing in streams and rivers, and tumbling in ocean waves. Water travels slowly underground, seeping and filtering through particles of soil and pores within rocks.

Although unseen, water's most dramatic movements take place during its gaseous phase. Water is constantly evaporating, changing from a liquid to a gas. As a vapor, it travels through the atmosphere over Earth's surface. In fact, water vapor surrounds us all the time. Where it condenses and returns to Earth depends upon loss of heat energy, gravity and the structure of Earth's surface.

Water condensation can be seen as dew on plants or water droplets on the outside of a glass of cold water. In clouds, water molecules collect on tiny dust particles. Eventually, the water droplets become too heavy and gravity pulls the water to Earth.

Living organisms also help move water. Humans and other animals carry water within their bodies, transporting it from one location to another. Water is either directly consumed by animals or is removed from foods during digestion. Water is excreted as a liquid or leaves as a gas, usually through respiration. When water is present on the
skin of an animal (for example, as perspiration), evaporation may occur.

The greatest movers of water among living organisms are plants. The roots of plants absorb water. Some of this water is used within the body of the plant, but most of it travels up through the plant to the leaf surface. When water reaches the leaves, it is exposed to the air and the Sun's energy and is easily evaporated. This process is called transpiration.

All of these processes work together to move water around, through and over Earth.

**Procedure**

**Warm Up**
- Ask students to identify the different places water can go as it moves through and around Earth. Write their responses on the board.

**The Activity**
1. Tell students that they are going to become water molecules moving through the water cycle and that they will create a bracelet and a map to keep track of their movements.
2. Categorize the places water can move through into nine stations: clouds, plants, animals, rivers, oceans, lakes, ground water, soil and glaciers. Write these names on large pieces of paper and put them in locations around the room or yard. (Students may illustrate station labels.) Leave a container of beads of a single color at each station (for example, pink equals glaciers, brown equals soil). Alternatively, the stations can be set up before the activity begins to save time.
3. Give each student a bracelet and a single yellow bead. They can assemble the initial bracelet themselves by tying a knot in one end and threading the yellow bead, or the bracelets can be preassembled before the activity. Ask students what the yellow bead might signify.
4. Explain that the yellow bead is meant to represent the Sun, since energy from the Sun helps drive the water cycle.
5. Give each student a Water Journey Map and pencil. Students will use this to record their journey through the water cycle. Tell students to draw arrows to each station they move to. Students should also record anytime they stay at a station. They may do this with a symbol of their choosing, such as a star or a circle.
6. Tell students that they will be divided among the nine stations. Students can choose a station to begin, or bracelets can be prethreaded with a second bead to assign students to a specific station. Ask students to move to their first station.
7. Have students identify the different places water can go from their station in the water cycle. Discuss the conditions that cause the water to move. Explain that water movement depends on energy from the Sun, electromagnetic energy and gravity. Sometimes water will not go anywhere.
8. After students have written their lists, have each group share their work. The cube for each station can be handed to that group, and they can check to see if they covered all the places water can go. The Water Cycle Table provides an explanation of water movements from each station.
9. Students should discuss the form in which water moves from one location to another. Most of the movement from one station to another will take place when water is in its liquid form. However, anytime water moves to the clouds, it is in the form of water vapor, with molecules moving rapidly and apart from each other.
10. In this game, a roll of a cube determines where water will go. Students line up behind the cube at their station. Students roll the cube and go to the location indicated by the label facing up. If they roll “stay,” they take a bead and move to the back of the line. When students arrive at the next station, they get in line. When they reach the front of the line, they roll the cube and move to the next station (or proceed to the back of the line if they roll stay).
11. Students should keep track of their movements by taking one bead from the station and placing it on their string and noting their movement on the Water Journey Map. Students should take one bead for each turn, including "stays."
12. Tell students the game will begin and end with the sound of a bell (or buzzer or whistle). Begin the game!

**Wrap Up**
- Have students use their bracelets and travel records to write stories about the places water has been. They should include a description of what conditions were necessary for water to move to each location and the state water was in as it moved. Discuss any cycling that took place (that is, if any students returned to the same station). Especially when using the travel records, students should be able to see clearly the interconnected "web" of water.
  - Provide students with a location (e.g., parking lot, stream, glacier or one from the human body—bladder) and have them identify ways water can move to and from that site. Have them identify the states of the water.
  - Have older students teach "The Incredible Journey" to younger students.
The Incredible Journey

Project WET Reading Corner

Explore the complexity of snow's structure and its relationship to water chemistry and the water cycle.

The story of a single drop of water is followed through cons of Earth's history.

The work of various Antarctic scientists is chronicled, along with a history of exploration at the bottom of the world.

Using haiku-like text and illustrations, this book pays tribute to water and the water cycle.

Illustrated booklet that shows what watersheds are and how they can be protected.

Students play a water cycle board game, "The Incredible Journey," in addition to exploring other water concepts.

Relive the first expeditions to the North Pole and discuss present-day problems of melting sea ice.

Engaging book filled with interesting facts about the water cycle.

Follow a single drop of water as it travels from place to place and season to season.

Assessment
Have students:
- identify the states water is in while moving through the water cycle (step 8: Wrap Up).
- describe the processes that move water (Warm Up: step 7; Wrap Up).
- write a story describing the movement of water (Wrap Up).

Extensions
Have students compare the movement of water during different seasons and at different locations around the globe. They can adapt the game (e.g., change the faces of the cubes, add alternative stations) to represent these different conditions or locations.

Have students investigate how water becomes polluted and is cleaned as it moves through the water cycle. For instance, as it travels through the soil, water might pick up contaminants, which are then left behind as water evaporates at the surface. Challenge students to adapt "The Incredible Journey" to include these processes. For example, rolled-up pieces of masking tape can represent pollutants and be stuck to students as they travel to the soil station. Some materials will be filtered out as the water moves to the lake. Show this by having students rub their arms to slough off some tape. If they roll clouds, they remove all the tape: when water evaporates, it leaves pollutants behind.

Visit the local water authority to find out more about water in the community. Where does municipal water come from (e.g., ground or surface water)? What are the local issues associated with water supply? How would the issues affect the water cycle?

Create a photo or video documentary of the local watershed that represents each aspect of the water cycle to print in the local or school newspaper or to post online to a blog or video site.

Teacher Resources
Books

Journals


<table>
<thead>
<tr>
<th>STATION</th>
<th>CUBE SIDE LABELS</th>
<th>EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>one side <strong>plant</strong></td>
<td>Water is absorbed by plant roots.</td>
</tr>
<tr>
<td></td>
<td>one side <strong>river</strong></td>
<td>The soil is saturated, so water runs off into a river.</td>
</tr>
<tr>
<td></td>
<td>one side <strong>ground water</strong></td>
<td>Water is pulled by gravity; it filters into the soil.</td>
</tr>
<tr>
<td></td>
<td>two sides <strong>clouds</strong></td>
<td>Heat energy is added to the water, so the water evaporates and goes to the clouds.</td>
</tr>
<tr>
<td></td>
<td>one side <strong>stay</strong></td>
<td>Water remains on the surface (perhaps in a puddle or adhering to a soil particle).</td>
</tr>
<tr>
<td>Plant</td>
<td>four sides <strong>clouds</strong></td>
<td>Water leaves the plant through the process of transpiration.</td>
</tr>
<tr>
<td></td>
<td>two sides <strong>stay</strong></td>
<td>Water is used by the plant and stays in the cells.</td>
</tr>
<tr>
<td>River</td>
<td>one side <strong>lake</strong></td>
<td>Water flows into a lake.</td>
</tr>
<tr>
<td></td>
<td>one side <strong>ground water</strong></td>
<td>Water is pulled by gravity; it filters into the soil.</td>
</tr>
<tr>
<td></td>
<td>one side <strong>ocean</strong></td>
<td>Water flows into the ocean.</td>
</tr>
<tr>
<td></td>
<td>one side <strong>animal</strong></td>
<td>An animal drinks water.</td>
</tr>
<tr>
<td></td>
<td>one side <strong>clouds</strong></td>
<td>Heat energy is added to the water, so the water evaporates and goes to the clouds.</td>
</tr>
<tr>
<td></td>
<td>one side <strong>stay</strong></td>
<td>Water remains in the current of the river.</td>
</tr>
<tr>
<td>Clouds</td>
<td>one side <strong>soil</strong></td>
<td>Water condenses and falls on soil.</td>
</tr>
<tr>
<td></td>
<td>one side <strong>glacier</strong></td>
<td>Water condenses and falls as snow onto a glacier.</td>
</tr>
<tr>
<td></td>
<td>one side <strong>lake</strong></td>
<td>Water condenses and falls into a lake.</td>
</tr>
<tr>
<td></td>
<td>two sides <strong>ocean</strong></td>
<td>Water condenses and falls into the ocean.</td>
</tr>
<tr>
<td></td>
<td>one side <strong>stay</strong></td>
<td>Water remains as a water droplet clinging to a dust particle.</td>
</tr>
<tr>
<td>STATION</td>
<td>CUBE SIDE LABELS</td>
<td>EXPLANATION</td>
</tr>
<tr>
<td>---------</td>
<td>------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Ocean</td>
<td>two sides <em>clouds</em></td>
<td>Heat energy is added to the water, so the water evaporates and goes to the clouds.</td>
</tr>
<tr>
<td></td>
<td>four sides <em>stay</em></td>
<td>Water remains in the ocean.</td>
</tr>
<tr>
<td>Lake</td>
<td>one side <em>ground water</em></td>
<td>Water is pulled by gravity; it filters into the soil.</td>
</tr>
<tr>
<td></td>
<td>one side <em>animal</em></td>
<td>An animal drinks water.</td>
</tr>
<tr>
<td></td>
<td>one side <em>river</em></td>
<td>Water flows into a river.</td>
</tr>
<tr>
<td></td>
<td>one side <em>clouds</em></td>
<td>Heat energy is added to the water, so the water evaporates and goes to the clouds.</td>
</tr>
<tr>
<td></td>
<td>two sides <em>stay</em></td>
<td>Water remains within the lake or estuary.</td>
</tr>
<tr>
<td>Animal</td>
<td>two sides <em>soil</em></td>
<td>Water is excreted through feces and urine.</td>
</tr>
<tr>
<td></td>
<td>three sides <em>clouds</em></td>
<td>Water is respired or evaporated from the body.</td>
</tr>
<tr>
<td></td>
<td>one side <em>stay</em></td>
<td>Water is incorporated into the body.</td>
</tr>
<tr>
<td>Ground Water</td>
<td>one side <em>river</em></td>
<td>Water filters into a river.</td>
</tr>
<tr>
<td></td>
<td>two sides <em>lake</em></td>
<td>Water filters into a lake.</td>
</tr>
<tr>
<td></td>
<td>three sides <em>stay</em></td>
<td>Water stays underground.</td>
</tr>
<tr>
<td>Glacier</td>
<td>one side <em>ground water</em></td>
<td>Ice melts and water filters into the ground.</td>
</tr>
<tr>
<td></td>
<td>one side <em>clouds</em></td>
<td>Ice evaporates and water goes to the clouds (sublimation).</td>
</tr>
<tr>
<td></td>
<td>one side <em>river</em></td>
<td>Ice melts and water flows into a river.</td>
</tr>
<tr>
<td></td>
<td>three sides <em>stay</em></td>
<td>Ice stays frozen in the glacier.</td>
</tr>
</tbody>
</table>
ALL THE WATER IN THE WORLD

Objectives:
Using this Project WILD activity, students will:
- calculate the percentage of freshwater available for human use.
- explain why water is a limited resource.

Materials:
- 1-L container (a soda bottle will work)
- 100-ml graduated cylinder
- eyedropper
- ice cube tray
- small container (another dish will work)
- salt
- drawing paper
- colored markers

Background:
Students may know the earth is covered mainly by water, but they may not realize that only a small fraction is available for human consumption. Learning that water is a limited resource helps students appreciate the need to use water resources wisely and to protect wetlands, watersheds, caves, and groundwater.

Procedure:
1. Tell the students that they are going to estimate the proportion of drinkable (potable) and non-potable water on the planet. Discuss what makes water unavailable for human consumption. (Saltwater, water trapped in glaciers, pollution, etc.)
2. Break students into small groups. Have each group draw a large circle with a marker on a white sheet of paper.
3. Have each group draw a pie chart showing their estimates of potable and non-potable water.
4. Show the class a liter of water and tell them it represents all the water in the world. Ask where most of the water on earth is located (the oceans). Refer to a globe or map if necessary. Pour 30 ml of the water into a 100-ml graduated cylinder. This represents the earth's freshwater, about 3 percent of the total. Put salt into the remaining 970 ml to simulate water found in oceans, unfit for human consumption.
5. Ask where most of the remaining water might be. Almost 80 percent of the earth's freshwater is frozen in ice caps and glaciers. Pour 6 ml of fresh water into a small dish and place the rest (24 ml) in an ice tray. The water in the dish (around 0.6 percent of the total) represents non-frozen freshwater.
6. Ask students where some of the rest of the water might be trapped. 4.5 ml of the water is underground. Fifty percent of the people in the United States get their drinking water from underground wells, but not all of the groundwater is reachable.
7. Using an eyedropper, remove a single drop of water (0.003 ml) from the dish and drop into someone’s hand. This represents clean, fresh surface water (from lakes and streams) which is not polluted or otherwise unavailable for use. This is about 0.00003 percent of the total! This precious drop must be managed properly.
8. Ask students to compare their original pie graph of the dispersal of water with what they just learned.

Wrap up:
Discuss the results of the demonstration. At this point students should conclude that a very small amount of water is available for human use. Remind the class of their earlier guesses at how much water is available to humans and compare with the actual percent available. Have students explain their reasoning for their initial estimates. Discuss whether there is enough water available for the current population. There are 8.4 million liters of water available for the 6 billion people on earth. Theoretically, this exceeds the amount of water one person would require in a lifetime. So, why does more than one third of the population not have access to clean water? Discuss the main factors affecting water distribution on earth. Students can also consider that other organisms use water, too. Discuss what the class can do with the water used in this demonstration to keep from wasting it.
Part 2:
1. Have students record how many gallons of water they think they use individually in an average day. Later, they will compare this estimated daily water use with their calculated daily water use.

2. As a group, have them list all the ways members of their class use water on a day-to-day basis.

3. Using the data in the table, "Domestic Uses of Water," have them determine their individual water use per day for each activity that the class listed in step 2. They should include their share of general family uses such as dishwasher and clothes washer. Then they can determine their individual total water use per day.

4. Students should compare the individual water use calculated in step 3 with the water use estimated in step 1. Are their calculated figures higher or lower than their estimated figures? Ask students whether they consider themselves typical water users. Have them explain their answers.

5. Students should now draw a bar graph to illustrate how much water is used by their class for each activity. Which activities require the most water? Using the class average, students should also calculate the average use of their town and/or state.

Suggested Answers to Student Worksheet Questions:
1. Water is needed to grow the food and grasses the calf would consume.

2. Student answers will vary.

3. Student answers will vary.

4. Possible answers: purchasing and eating foods which require less water to cultivate (eating lower on the food chain); recycling items to prevent excessive use of water in manufacturing; driving less.

5. Possible answers: take showers instead of baths; don't let water run while brushing teeth or shaving; fix leaky faucets; install water-saving devices for toilet and shower; water lawn less frequently; run dishwasher and washing machine only when you have full loads.

6. Student answers will vary. For further information on water contamination, you may wish to contact the U.S. Environmental Protection Agency, Public Information Center, 401 M Street, SW, Washington, DC 20460; 202/293-3358, www.epa.gov.

Follow-up Activities:
1. Have students investigate new household products which conserve water (such as low-flush toilets, new shower heads, timed sprinklers, etc.) Each student or group of students could be responsible for writing up a brief synopsis of the costs and benefits of one or two of these products. (Note: Free catalogs listing water conservation devices are available from: Eco Source, 610 Wendell Court, Atlanta, GA 30336, 800/869-2737; and Galcon Inc., 1 Mill St., Suite A26, Burlington, VT 05401, 800/456-1177.)

2. Have students read their home water meter daily for a week, at the same time each day, and report back to the class. They can then compare these readings to their estimates of daily water use. They can then read the meter for a second week, in which they implement many of the conservation measures suggested above.

Adapted by permission from Biological Science Curriculum Study. The original activity appears in Biological Science: An Ecological Approach (Randall/Scott Publishing Company, 1987, 1992, 1996).
# Water, Water Everywhere

## Domestic Uses of Water

<table>
<thead>
<tr>
<th>Activity</th>
<th>Gallons Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brushing teeth</td>
<td>2-10</td>
</tr>
<tr>
<td>Washing hands</td>
<td>2</td>
</tr>
<tr>
<td>Shaving</td>
<td>20 (2/min.)</td>
</tr>
<tr>
<td>Showering</td>
<td>20-25 (5/min.)</td>
</tr>
<tr>
<td>Tub bathing</td>
<td>25-35</td>
</tr>
<tr>
<td>Flushing toilet</td>
<td>3.5 - 8</td>
</tr>
<tr>
<td>Getting a drink</td>
<td>0.25</td>
</tr>
<tr>
<td>Cooking a meal</td>
<td>5-7</td>
</tr>
<tr>
<td>Washing dishes</td>
<td>30 (8-10/meal)</td>
</tr>
<tr>
<td>Automatic dishwasher</td>
<td>15</td>
</tr>
<tr>
<td>House cleaning</td>
<td>7</td>
</tr>
<tr>
<td>Washing machine</td>
<td>24-50</td>
</tr>
<tr>
<td>Watering lawn</td>
<td>10/min. (102/1000 m³)</td>
</tr>
<tr>
<td>Leaking faucet</td>
<td>25-50/day</td>
</tr>
</tbody>
</table>

(Faucet and toilet leaks in New York City = 757 million gallons/day)

## Indirect Uses of Water

### Agricultural

<table>
<thead>
<tr>
<th>Item</th>
<th>Gallons Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kg corn</td>
<td>374</td>
</tr>
<tr>
<td>1 loaf of bread</td>
<td>150</td>
</tr>
<tr>
<td>1 kg rice</td>
<td>1,232</td>
</tr>
<tr>
<td>1 kg grain-fed beef</td>
<td>1,760</td>
</tr>
<tr>
<td>1 kg cotton</td>
<td>4,400</td>
</tr>
</tbody>
</table>

### Industrial

<table>
<thead>
<tr>
<th>Item</th>
<th>Gallons Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 gallon gasoline</td>
<td>10</td>
</tr>
<tr>
<td>1 kg steel</td>
<td>25</td>
</tr>
<tr>
<td>1 kw electricity</td>
<td>80</td>
</tr>
<tr>
<td>1 kg paper</td>
<td>220</td>
</tr>
<tr>
<td>1 kg synthetic rubber</td>
<td>660</td>
</tr>
<tr>
<td>1 kg aluminum</td>
<td>2,200</td>
</tr>
<tr>
<td>1 car</td>
<td>100,000</td>
</tr>
</tbody>
</table>
1. There are many water uses that are not obvious to most people. Consider, for example, that 1.2 million gallons of water are needed to raise one calf until it is fully grown. Why do you think so much water is needed to raise a calf?

2. Make a list of the ways you use water indirectly, for example, in the production of food you eat or materials you use.

3. Compare your list with the table above, “Indirect Uses of Water.” How many of these uses did you list?

4. How could you reduce your indirect use of water?

5. What could you do to reduce your direct use of water?

6. Is there any evidence that the water supply you use daily is decreasing in size or is being contaminated by pollutants? How could you go about obtaining this information?
Water Footprint Assignment

This assignment consists of three parts.

First, calculate your water footprint in 3 ways.

Second, do the readings.

Third, answer the questions given.

Part 1 - Calculate your water footprint in three ways, keeping track of the information the calculators are using to make their estimates, along with your results. First, use the quick calculator (first citation below), then work through the extended calculator (second citation below) and see how your footprints compare. Third, work through either calculator, but change your country or some other input. Record your result in your notebook.

Water Footprint Calculators


Part 2 - Read the articles listed below under Readings. This will help you assess the concept, value, and uncertainties of water footprints.

Readings


Part 3 – Final submission

1) Provide the results of your water footprint quizzes.
2) Write a paragraph comparing the results, your take on their relative accuracy, and the impact of changing your country of origin or some other input.
3) Write a paragraph consisting of your assessment of the value of water footprint analysis. What is to be learned from it? How can it be used? What are its limitations?

Adapted from: https://serc.carleton.edu/integrate/teaching_materials/water_sustainability/unit2.html
Appendix F
Lesson Plan: Day 6

<table>
<thead>
<tr>
<th><strong>Standard:</strong> The sun is the principal external energy source for the Earth.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Benchmark:</strong> 8.3.2.1.3 Explain how heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and hydrosphere producing winds, ocean currents and the water cycle, as well as influencing global climate.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Essential Question(s):</strong></th>
</tr>
</thead>
</table>

- How does sun play a major role in controlling water cycle?
- How does the Sun’s energy move through each sub-system (atmosphere, oceans, water cycle, and food chains)?

<table>
<thead>
<tr>
<th><strong>Lesson Objective:</strong> Student will be able to</th>
</tr>
</thead>
</table>

- understand how sun helps with the water cycle
- explain how does the solar energy move through the atmosphere, oceans, water cycle and food chains

<table>
<thead>
<tr>
<th><strong>Materials Required:</strong></th>
</tr>
</thead>
</table>

- **Sun and Water cycle:** Plastic bowl clear or colored but not white, salt 8 grams, water 250 milliliters, Plastic spoon
- **Importance of sun’s energy thank you cards:** Card stock paper for thank you cards, coloring supplies

<table>
<thead>
<tr>
<th><strong>Time Required:</strong> 1 60-minute class period</th>
</tr>
</thead>
</table>

| **Prior learning activities completed before this lesson:** knowledge of water cycle and |
vocabulary associated with it.

<table>
<thead>
<tr>
<th>Lesson Format - What will students learn?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day 6</strong></td>
</tr>
<tr>
<td>(30 mins) <strong>Sun and Water Cycle</strong> - Read with the students and discuss questions</td>
</tr>
<tr>
<td>(30 mins) <strong>Importance of Sun’s energy: Thank you cards</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment - How will I know the students have learned?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Student discussion on sun and water cycle</td>
</tr>
<tr>
<td>• Detailed thank you cards</td>
</tr>
</tbody>
</table>

**Connection or bridge to next lesson:** Students learned about biotic and abiotic factors essential to living beings and how sun plays a major role in aiding water cycle. In the next lesson, students will look at human impact on natural processes.

**How does this lesson fit into the Unit?** It’s important to understand sun’s impact on earth and how Sun’s energy move through each sub-system (atmosphere, oceans, water cycle, and food chains). This will provide students with a better comparison how human activities have affected natural processes.
The last time you took a shower, did you think about where the water came from? Sure, it came out of the showerhead, but what about before that? The water you used to wash could have spent time in the South China Sea. Or maybe it was part of an ancient glacier at the South Pole.

The water in your shower could have come from anywhere in the world because all of Earth's water is recycled in a process called the water cycle. So just how does water from a glacier halfway around the world find its way to your bathroom?

How does the Sun move water in the water cycle from the oceans?

Water is the only substance on Earth that exists in all three states of matter naturally. Water can be solid ice, a flowing liquid, or gaseous vapor. When water moves through the water cycle it changes between these states of matter over and over again. The water cycle is the process that water moves through between the air and Earth's surface. The water cycle is powered by heat energy from the Sun.

A cycle is like a circle—it has no beginning and no end. However, we'll start looking at the water cycle in the ocean. Approximately 70% of Earth's surface is covered in ocean water. When water at the ocean's surface is heated by the Sun it gains energy. With enough energy, the molecules of liquid water change into water vapor and move into the air. This process is called evaporation. The water in the ocean is mostly saltwater, a mixture of salt and water. When evaporation happens only the water evaporates. The salt is left behind.

Wherever water is heated by the Sun, evaporation can occur. Water evaporates from lakes, rivers, puddles, soil, and even your body. When sweat dries on your skin, it is because the water in sweat has evaporated into the air. You may have noticed that when sweat evaporates off of you, your skin feels and tastes salty. Similar to the oceans, sweat is saltwater. The water evaporates, and the salt is left behind on your dry skin.
When the Sun’s energy interacts with ocean water, evaporation takes place. Take a moment to model how this part of the water cycle works. For this activity, you will need:

- Plastic bowl, clear or colored but not white
- Salt, 8 grams
- Water, 250 milliliters
- Plastic spoon

1. Add the water and the salt to the bowl. Mix them together well with the spoon so they form saltwater.
2. Set the bowl in a warm, sunny place. If possible, place the bowl outside in the Sun. If that’s not possible, place it in a sunny spot inside, such as a windowsill.
3. Check the bowl after several hours or the next day. How warm the bowl of water gets will affect how long you should leave it in the sunlight. The warmer the area, the less time you will need.
4. What happened to the water in the bowl? What happened to the salt in the bowl? How does this experiment model what happens in the oceans? Is the water from your bowl part of the water cycle? Where is it now?

What are the different components of the water cycle?
After water evaporates from the surface of the land, it enters the atmosphere. Warm air carries water vapor to the upper parts of the atmosphere. There it begins to cool because of the low temperatures. As water vapor cools, the water particles huddle close together. They form very small droplets of liquid water. The process in which water vapor changes back into liquid water is called condensation. Condensation is the opposite of evaporation. The tiny droplets of water eventually collect and form a cloud. When droplets get large enough they can fall to the ground as rain or snow.

Fluffy, white clouds in the sky seem like they are giant puffs of vapor floating in the air. Because they float high above the ground, many people think clouds are gas. But clouds are actually liquid water. The gas form of water, water vapor, is invisible. You cannot see water vapor, but you can feel it when you hold your hand above a pot of boiling water or step outside on a humid day. Because you can see clouds, you know they are not water vapor. They are made up of very small droplets of liquid water that have condensed on bits of dust floating in the atmosphere. The same is true of steam and fog.
As water vapor condenses in the atmosphere, the droplets become larger and the cloud gets heavy. When it becomes too heavy, the cloud releases the water droplets. They fall back to Earth as precipitation. There are many types of precipitation including rain, snow, hail, and sleet. Much of the water returns to the ocean and the water cycle begins again.

Water that falls onto land can take many pathways. It may run off the land and collect in lakes, rivers, and puddles. The Sun warms these bodies of water as well, and evaporation takes place. Some precipitation may soak into the ground. When this happens, there is a good chance that a living organism will use it. For example, a plant may absorb water from the soil or an animal may drink from a stream. Living things take in water and can release it as well. Plants release water into the atmosphere through their leaves. Animals release it through sweat and urination. In both cases, the Sun's energy causes the water to evaporate, and the water cycle continues.

What do you think?

Evaporation, condensation, and precipitation are all parts of the water cycle. Look at the pictures below of water in different stages of the cycle. Which process in the water cycle will the water in each picture go through next?
How does the Sun affect weather patterns that move water and form precipitation? The Sun’s energy and the water cycle play important roles in the weather patterns seen on Earth. We have already seen how the water cycle causes weather conditions such as cloud cover, rain, and snow through evaporation, condensation, and precipitation.

When the Sun heats the ocean, it also heats the atmosphere and the land. However, different parts of Earth absorb different amounts of heat. As a result, the air is warmer in some places and cooler in others. Cold air is more dense than warm air, so it sinks closer to the surface of Earth. Warm air rises higher into the atmosphere. As it rises, the warm air cools. As it cools, it becomes more dense and sinks back to the ground. As air moves in the atmosphere, weather patterns change from storms and wind to clear and sunny skies.

What do you think?

Some of the water on Earth is frozen in glaciers and other forms of ice. How can frozen water move though the water cycle with the help of the Sun?

Looking to the Future: Changes to the Water Cycle

Many scientists agree that the average temperature on Earth is increasing. What does this mean for the water cycle? Rising temperatures mean an increase in evaporation. This leads to an increase in condensation in the atmosphere. Scientists predict that this will increase overall cloud cover, humidity, and precipitation across the globe. Higher air temperatures also mean that more precipitation will fall as rain. Snow, sleet, and hail result from low air temperatures. Increases in rainfall can cause rivers to overflow and put areas in greater danger of flooding. How else could rising global temperatures affect the water cycle?
What Do You Know?
The Sun's energy powers the water cycle. Water changes state—its temperature increases and decreases as it moves through different stages of the water cycle. Look at the scene from nature shown here. The numbers represent different parts of the water cycle. For each number, describe what is happening in the water cycle. Then draw arrows showing how water moves in a continuous cycle through each process.
Connecting with your child
To help your child learn more about the water cycle and the Sun, experience it together in nature. Take your child outside with a digital camera or other device that can take pictures. Have your child take a wide variety of pictures from nature that are related to the water cycle.
Suggestions include puddles, streams, the ocean, clouds, raindrops, snow banks, sunlight, and the sky. Encourage your child to be creative and to take pictures of unique examples of the water cycle such as soil, leaves, small animals, ice cubes, and people. If possible, have your child take multiple pictures of the same object to form a collage that exemplifies the variety found in nature. You can also have your child find examples of the water cycle inside the home. Suggestions include a steamy mirror, a glass of water, or a pot of boiling water. (Take precaution when children are around hot objects.)

After returning home, print out the pictures. Gather posterboard, glue or tape, and some markers. Using the pictures, have your child create a personal poster of the water cycle from your own backyard. Arrange the pictures according to the different stages of the water cycle that they represent. For example, all the cloud pictures could represent condensation. Use the markers to label and describe the parts of the water cycle. Then, have your child present the project to other family members, explaining what they learned about the Sun and the water cycle.

Here are some questions to discuss with your child:
- How do you interact with the water cycle every day?
- How does the amount of sunlight affect the water cycle? Does more evaporation take place at night or during the day? Why?
- How does air temperature affect the precipitation stage of the water cycle?
Thank You, Sun!
The Importance of the Sun’s Energy in the Earth System
Adapted from: http://home.d47.org/drwise/files/2014/09/thank_you_sun_solar_energy_in_earth_systems.pdf

In order for a system to work, it needs energy. Energy is what makes parts of a system move, change, and interact. Earth’s spheres (atmosphere, biosphere, hydrosphere, and lithosphere) all require energy. Where does this energy come from?

Our Earth gets most of its energy from the Sun. We call this energy “solar energy”. (“Sol” means sun.)

Solar energy travels from the Sun to the Earth in waves. These waves are often called rays. Some are in the form of light that we can see. Others, like x-rays, are invisible. The Earth receives only a tiny bit of the Sun’s total energy – but that equals a massive amount of energy on Earth.

When the Sun’s rays reach Earth, some are reflected back into space. The rest are absorbed by the Earth’s atmosphere, oceans, and land, and turned into heat. This heat warms Earth, the oceans, and the atmosphere. Without this heat, we couldn’t live on Earth – it would be too cold.
The Sun’s energy is constantly being moved around Earth, and is the energy that powers many of Earth’s processes. In this lesson, you will understand how the Sun’s energy is important to powering winds in the atmosphere; currents in the ocean; the water cycle; and food chains.

As you read, you will summarize the following in your “thank you card” for each sub-system:

11. How does the Sun’s energy move through each sub-system (atmosphere, oceans, water cycle, and food chains)?
12. How does this energy affect the system (what things happen on Earth because of it)?
13. What would happen to each sub-system if there were no Sun?
14. Draw a diagram to represent the flow of the Sun’s energy through each sub-system.

Solar Energy in the Atmosphere (Wind)

Solar energy makes the winds that blow over Earth. This happens by the process of convection currents. When the Sun shines on Earth, some parts heat up more quickly than others. Solid land, for example, heats up quicker than water in the oceans. The air over the land gets warm, and the warm air rises. The cooler air over the water moves in where the warm air was. This moving air is wind.

Wind is how the Sun’s energy moves around Earth’s atmosphere. It is much warmer near the equator (the imaginary line around the middle of Earth) than it is near the North and South poles. This temperature difference causes winds that circle Earth. They are a major factor for weather that creates the many different climates on Earth (deserts, rainforests, tundras, grasslands, etc.).
These arrows represent wind that is moving all around Earth. This moving air also moves heat around Earth, creating different climate zones.

**Solar Energy in the HYDROSPHERE: Oceans (Currents)**

One special property of water is that it is able to absorb large amounts of heat. Because the oceans make up 70% of Earth, there is a lot of heat in the oceans (even though they feel cool). Ocean waters closer to the equator receive more of the Sun’s heat than ocean waters near the poles. Like the atmosphere, this temperature difference creates convection currents in the ocean. Warmer water rises up, and cooler water flows in to take its place, creating ocean currents.

Ocean currents transport water all over the globe. This is helpful because these currents also carry important nutrients to different places on Earth. Ocean currents are also important to weather. Scientists now understand that the massive amount of heat energy in the ocean affects the weather patterns in the atmosphere above. Warm ocean water meeting cold ocean water results in tropical storms and hurricanes.
Solar Energy IN THE HYDROSPHERE: Water Cycle

Oceans are not the only way that water moves around earth. Solar energy powers the water cycle. The water cycle is how water moves through, and between, Earth’s land, oceans, and atmosphere. First, the Sun heats water on Earth. The water evaporates – it turns into a gas called water vapor that rises into the atmosphere. The air in the atmosphere is cooler, so the water vapor condenses (turns back into liquid water) and forms clouds. The water falls from the clouds as precipitation – rain, snow, sleet, or hail – and returns to Earth’s surface.

The water cycle is another important factor in temperature and weather. The water cycle brings us fresh water in the form of precipitation. Without the water cycle, life on Earth would not be possible.

Solar Energy IN THE BIOSPHERE (Food Chains)

Solar energy also affects living things. All food chains begin with solar energy. The Sun provides light energy to plants. Plants use that energy to make food. This is called photosynthesis. The food is stored as chemical energy. When animals eat the plants, the chemical energy is passed from the plant to the animal. If that animal gets eaten, the chemical energy gets passed from animal to animal.
Food chains are how energy gets transferred through living things. Food chains are an important part of ecosystems around the world. But without the Sun’s light energy to start the process, food chains would never begin, and life on Earth would not be possible. So it’s not just plants that depend on the Sun’s energy – it’s us, too!

What about the lithosphere?

We have learned how the Sun gives energy to the atmosphere, hydrosphere, and biosphere. But what about the lithosphere (the rock materials on Earth)? Well, the lithosphere does not really use energy from the Sun. The lithosphere gets energy from another source – heat inside of Earth. That is another lesson that we will learn later! For now, you should just concentrate on the three Earth spheres that are powered by the Sun.

Thank you, Sun – for all you do!
Appendix G

Lesson Plan: Day 7, 8, 9 & 10

**Standard:** In order to maintain and improve their existence humans interact with and influence Earth systems.

**Benchmark:** 8.3.4.1.2 Recognize that land and water use practices affect natural processes and that natural processes interfere and interact with human systems. For example: Levees change the natural flooding process of a river. Another example: Agricultural runoff influences natural systems far from the source.

**Essential Question(s):**

How have human after only being on the earth for a short amount of time caused so much havoc?

What can be done to reverse the damage humans have caused on the earth?

**Lesson Objective:** Students will be able to:

- explain what are watersheds and their importance
- discuss what is pollution and how it affects our water stream
- understand what is run-off and discuss how it affects our system

**Materials Required:**

**Humpty Dumpty:** Photos of altered site, object with multiple parts that could be disassembled, hardboiled egg, old magazines, glue, scissors, ruler, drawing material, poster board

**Make-a-Mural:** Copies of topic cards, long piece of newsprint, assorted tempera paints, finger paints, paint brushes, egg cartons, kitchen sponges, empty coffee cans, packing tape, scissors,
What’s been polluting groundwater: copies of activity handouts, clear plastic soda bottle, old nylon stockings or tights, rubber band, clean gravel, clean sand, water, beaker, measuring spoon, rain cups (paper cups with holes punched in the bottom), table salt, eyedropper, red and blue food coloring, vegetable oil, paper towel, baking soda, vinegar

Terraqua Column: two 2-liter bottles, one bottle cap, bottle biology kit, fabric interfacing or cotton string, water, soil and plants

Conservation discussion: worksheet copies for students

Time Required:
3 60-minute class periods (required)
1 60-minute class period (optional)

Prior learning activities completed before this lesson: Students will come in with the knowledge of water cycle, vocabulary and that sun is the ultimate source of energy on this earth.

Lesson Format - What will students learn?

Day 7
(60 mins) Humpty Dumpty Lab

Day 8 (optional)
(30 mins) Make a mural
(30 mins) What’s been polluting the ground water lab

Day 9
(60 mins) Run off experiment for bottle Biology Terraqua column

Day 10
(30 mins) Finish working with Terraqua column experiment
(15 mins) **Discussion on conservation**
(15 mins) **Post-test**

**Assessment - How will I know the students have learned?**

- Humpty dumpty project and discussion of the relationship of the exercise to real-life restoration project
- Develop a definition of watershed and identify their local watershed through an internet search. Students can also research the natural and human elements in their local watershed.
- Groundwater model conclusion worksheet
- Students will develop their own science experiment after observing terraqua column

Conservation discussion worksheet

**Connection or bridge to next lesson:** This unit can lead to either physical properties of water or biochemistry. This unit can provide a leeway to ecology unit as well.

**How does this lesson fit into the Unit?** After gaining understanding around biotic and abiotic factors present in nature, students will explore impact of human activities that are destroying natural resources. Also, what steps can be taken to restore natural elements in nature.
Humpty Dumpty

What would Humpty Dumpty have looked like if they could have put him back together again?

Grade Level
Upper Elementary, Middle School

Subject Areas
Government, Environmental Science

Duration
Preparation time: Option 1: 15 minutes; Option 2: 30 minutes; Option 3: 15 minutes
Activity time: Option 1: 50 minutes; Option 2: 50 minutes; Option 3: 50 minutes

Setting
Classroom

Skills
Organizing information (arranging, manipulating materials); Analyzing; Applying (planning, designing, problem-solving, developing and implementing investigations and action plans)

Charting the Course
To understand how water flows through a watershed, students should participate in “Seeing Watersheds” and “Blue River.” In “Humpty Dumpty,” students recognize how difficult it is to restore a watershed once it has been disturbed. In “The Price is Right,” students are introduced to the costs of water projects, a critical aspect of restoration.

Vocabulary
ecosystem, restoration, biological systems, watersheds, geology, topography, climate, weather, material cycles, diversity, mining, draining, channelizing, contamination, groundwater, erosion, saltwater intrusion, ecological niches, food chains, pyramids of numbers, predator-prey relationships, land reclamation, wetland, hazardous waste site, Everglades

Summary
Students relate the challenges of environmental restoration projects to piecing together puzzles, broken items or clay pots.

Objectives
Students will:
- describe the challenges of restoring an altered natural environment.
- develop a restoration plan for a local site.

Materials
Warm Up
- Photos of altered sites
- Object with multiple parts that could be disassembled (e.g., an old clock)
- A hard-boiled egg

For Option 1:
- Pattern for puzzle (Select a simple or more complex pattern.)
- Old magazines
- Glue
- Scissors
- Ruler
- Drawing materials
- Poster board or tagboard

For Option 2:
- Old radios, clocks, telephones or other objects containing multiple parts
- Hand tools (screwdriver, wrench, hammer, pliers)
- Nails

For Option 3:
- Small clay or terracotta flower pots (one per small group of students)
- Digital camera (optional)
- Paper bags large enough to hold one of the flower pots
- Safety goggles
- Paper plates
- Glue

Making Connections
Some students may have tinkered with the insides of a clock or radio and learned that taking something apart is easier than putting it back together. Other students may have broken a vase or a dish and discovered that even after it is glued back together, it is never quite the same as it was before. Comparing restoration projects to completing a jigsaw puzzle or to repairing something that has been broken helps students appreciate the challenges watershed managers face as they attempt to restore altered water environments to their natural states.

Background
Some things, like bicycles, old clocks and puzzles, can be taken apart and put back together. More complex things, such as biological systems, watersheds and wetlands, are quite difficult to restore (to create a healthy system with a structure and function similar to the original). Superficially, everything may look the same when put back together, but if parts are lost, left out or not put back in the proper relationship with the other parts, the ecosystem will not work effectively.
Natural systems (e.g., watersheds, ecosystems) are complex arrangements of physical factors (geology, topography, soils, climate and weather, material cycles, water, etc.) and biological components (plant and animal communities). While complexity and diversity tend to strengthen unaltered systems in nature, the more components and interrelationships those systems have, the more difficult it is to restore them if they become rearranged or damaged.

Natural systems can be altered by natural events (hurricanes, tornadoes, floods) and human activities. Human activities (mining, draining, channelizing, construction, etc.) may be necessary to meet the needs of growing populations. These practices often occurred before people were aware of the ecological consequences of altering ecosystems, which can include contamination of ground water, erosion, loss of wildlife species, saltwater intrusion, etc.

Ecological processes and associations—ecological niches, food chains, pyramids of numbers, predator-prey relationships and various material cycles (carbon, nitrogen, sulfur, water)—bind natural systems together like threads in a complex web of life. Restoration projects are undertaken in the hopes of returning ecological systems to their natural states. However, like an eggshell broken into many pieces with some crushed beyond repair, a fragmented ecosystem with permanently altered components may be difficult to "put back together again." In addition, since alterations to the system may have occurred many years ago, parts may be missing or knowledge of what the site originally looked like may be lost. Restoration is no substitute for protecting and preserving unaltered natural systems, but when systems have already been altered, the most promising solution is restoration.

Repair of contaminated or changed water environments is a shining example of both human ingenuity and Earth's ability to heal past wounds; some land and water can be restored to a healthier state, but not always completely.
restored to near natural conditions. Laws requiring land reclamation and protection have been in existence for decades. Once, restoring changed land and water resources was not even given consideration. It was standard operating procedure to use the land and water, then leave it. This may seem counterproductive today; however, 100, 50 or even 30 years ago, most land and water managers were not required to restore impacted sites.

Times have changed and so have people's attitudes about restoring the environment. Many impacted areas once considered contaminated beyond recovery or permanently altered are now being reconsidered for restoration projects. New technologies, laws, shifts in societal attitudes toward the environment and financial resources are making possible the restoration of previously forgotten or avoided sites. Government agencies, mining companies, logging firms, farmers, construction companies, developers and other landowners are presently involved in countless restoration projects.

Restoration can be viewed as a way to reclaim the past. It offers young people hope and optimism. A single student, a family, a neighborhood, a classroom or a school system can identify, guide, mobilize resources for and otherwise help a restoration project. Few accomplishments would have a more positive impact on young people than knowing that they helped restore a natural site.

Restoration is happening around the country and the world. The farmer who plugs a drain in a wetland and plants vegetation for wildlife habitat is playing a part. The industry that treats the soil and water of a polluted waste pond and turns the site into a park makes a difference. The government agency that begins the long process of restoring a hazardous waste site with plans of designating the site as a wildlife refuge makes a contribution. One of the largest restoration projects in the world is occurring in the
The Activity

Here are three options to simulate the concept of restoration.

Option 1
1. Divide the class into small groups. Distribute to each group a copy of a puzzle pattern. (Depending on time and students' skill level, the simple or more complex pattern may be selected.) Instruct group members to glue the pattern (face up) onto the poster board and cut around the circle. Distribute old magazines and have students locate nature scenes, preferably containing water. Tell them to cut out a picture and glue it to the poster board side. An alternative is for students to draw a picture of an ecosystem on the poster board.
2. Have students carefully cut the poster board on the lines of the pattern.
3. Instruct students to scatter the pieces on their desk top. Explain that this represents a natural area that has been altered.
4. Discuss complications of putting ecosystems back together again.
5. Tell students to arrange their pieces so the cut-up picture is face down. Have them switch pieces with another group. Without turning the pieces over, the groups should try to put the puzzles together again.
6. Have groups tape the puzzles together and turn the puzzles over. Some of the pictures may be accurately reconstructed, but because of pairs of mirror images that can be interchanged (without the visual clue of a picture to guide students), some may not. This emphasizes the point that the parts of a system must fit together properly and that incomplete knowledge of the parts (representing past knowledge) can complicate its restoration. (Even if the puzzle has been put together properly, it is still different from the original, because it has been cut apart.)

Option 2
1. Find several old, discarded items (e.g., frying pan with handle, clock, radio, toy) for students to dismantle. Objects should have a range of complexities.
2. Divide the class into groups equivalent to the number of objects available to dismantle. Some objects (such as a frying pan with handle) are relatively easy to assemble once dismantled and require few resources. This is analogous to restoring a spot on the school grounds where a delivery truck has left a tire track. A few scoops of soil, a little packing, some grass seeds and a few weeks the spot is gone. On the other hand, some restoration projects are of monumental scope, requiring huge amounts of money, energy and time. Use a dismantled clock to demonstrate this type of project.
3. Direct each group to dismantle an object into its smallest pieces. The pieces should be placed in a container marked with the group's number.
4. Have one group attempt to reassemble another group's object. Ask them to summarize the challenges of putting the pieces together again. Emphasize that many restoration projects are accomplished by persons other than those who dismantled or contaminated the environment.

5. Depending on the age of the students and the difficulty of disassembly and assembly of the objects, remove several parts from each object. These removed parts represent absent plants and animals or a significant change to a site's soil, air or water. How would students propose to reassemble objects without all the parts? Could they reconstruct some of the parts?

Option 3
1. Hand out markers and clay pots to small groups of students. Ask students to work together to decorate the pot with pictures that bring to mind a favorite natural place they know.

2. When they have finished drawing, ask for a volunteer from each group to explain to the class what they have drawn. Optional—if a digital camera is available, line the pots up on a table and take photos of them to be used as a before-and-after comparison.

3. Explain that natural events (such as floods, fires, hurricanes and tornadoes) and human activities (such as mining, agriculture, building construction, road construction and industry) affect ecosystems. What do the students think should be done when this happens? Explain that restoration is one solution and tell them what it is. Make a list of reasons to restore ecosystems (erosion control, flood control, conservation of biological diversity, conservation of water quality and quantity).

4. Explain that they will now experience first-hand how easy or hard it is to restore something. Tell the students that, unfortunately, their ecosystem (pot) has been changed due to a natural event or human activities. Distribute a paper bag to each group and have the students place their pot in it and close the bag securely.

5. Ask the students to trade bags with another group and then ask the students to drop the bag on the ground to break the pot (alter the ecosystem). Note: Emphasize to students that the bags should be dropped, not thrown, to the floor. If the pot gets smashed completely, students will not be able to "restore" the pots. Once the pot is broken, have students trade bags again. No group should have his or her original pot or the one that they broke. This will bring home the message that sometimes ecosystems must be repaired not by the original inhabitants or even the people who caused the damage.

6. Distribute glue and paper plates to each group. Ask them to remove the pieces from the bag and use glue to put them back together again. Many of the pieces will be large enough to work with. Others will be too small. This problem also occurs in real restoration efforts. Students should do their best to "restore" the pots as well as they can. Optional—Line up the pots in the same order as the first photo and take the "after" photo.

7. Have students share their successes and failures in their effort to restore their ecosystem (clay pot). Emphasize that some parts can be restored very well, but that others cannot. As with real ecosystems, the restored ecosystem will be similar to, but not exactly the same as, the original. How would students propose to reassemble objects without all the parts? Could they recon-

8. Remind students that even ecosystems that haven't been altered directly by human activities are in a constant state of dynamic, natural change. Natural events, such as forest fires, avalanches, floods, etc., are important ecosystem processes that create change and regeneration.

Wrap Up
* Discuss the relationship of the exercise to real-life restoration projects. Have students summarize why ecosystems are altered and why they are difficult to restore. Do students believe people might not alter ecosystems in the future?
* Recognizing the need for humans to continue using natural resources, ask students to identify strategies for maintaining the integrity of ecosystems (inventory plant and animal species, monitor water quality, employ best management practices, etc.).

ActionEducation™
* Have students identify a potential water-related restoration project. Students should consider the following: establishing a restoration goal, formulating a restoration plan, predicting difficulties, analyzing costs, determining a time frame, projecting results (e.g., illustrating the potential appearance of a restored site) and maintaining restored sites. If the project proves feasible and students undertake restoration of a site, have them maintain a project diary or water log and circulate copies to other teachers and students.
Like a broken egg, wetlands can be difficult, but not impossible, to put back together.

Project WET Reading Corner
Books

This book covers the human impact upon habitats and various natural cycles.


Students learn about the delicate ecosystem of mountainous tropical rain forests in Costa Rica.


This book chronicles the creation/restoration of a tallgrass prairie in Iowa, along with the plants and animals found there and their relationships.


Traces the causes and effects of various types of water and air pollution and describes wetland conservation.


A young boy’s grandfather dreams of restoring the Mekong Delta wetlands, hoping that the large cranes once there will return.


Through poetry, 14 threatened animals are featured, with information on each animal’s status.


Learn about erosion and its effects, not only from natural, but manmade sources, as well.


Learn about the Everglades from its size to the plants and animals found there.

*Listed on one or more state reading lists.

Assessment
Have students:
- explain or demonstrate why some altered systems cannot be restored to their original state (Option 1, step 4; Option 2, steps 4 and 5; Option 3, steps 4–7).
- relate the challenge of assembling the pieces of an old clock (radio, puzzle, etc.) to the challenge of real-life restoration projects (Option 1, step 6; Option 2, step 4; Option 3, steps 7–8).
- develop and participate in a restoration plan for a local site (Action Education™).

After completing the activity, for further assessment, have students:
- analyze the importance of restoration projects and the elements that contribute to success and failure.

Extensions
Have students research other water-related restoration projects that are underway locally, regionally or nationally.

Contact the Environmental Protection Agency, the U.S. Army Corps of Engineers and the Bureau of Reclamation for information about environmental restoration projects.

To see an example of a complex restoration, have students visit the official website of the Comprehensive Everglades Restoration Plan (www.evergladesplan.org). Students can prepare a brief news report (written or presented on video) about one aspect of the restoration. The combined work of the class can be put together as a newspaper, magazine or video news journal.

Teacher Resources
Books
Project WET Foundation and Environmental Concern Inc. 1995. *WOW! The Wonders Of Wetlands*. Published through a partnership between Environmental Concern Inc., St. Michaels, MD, and Project WET Foundation, Bozeman, MT.


Journals


Make-a-Mural

How do you picture your watershed?

**Grade Level**
Upper Elementary, Middle School, High School

**Subject Areas**
Fine Arts, Earth Science, Environmental Science, Geography, Government, History/Anthropology, Language Arts

**Duration**
Preparation time: 20 minutes
Activity time: Two 50-minute periods

**Setting**
Classroom

**Skills**
Gathering information; Organizing; Analyzing; Interpreting; Presenting

**Charting the Course**
"River Talk" provides an introduction to watersheds. Through "Seeing Watersheds," students map watershed boundaries. In "Blue River," students demonstrate how water flows in a watershed. "Color Me a Watershed" illustrates how watershed changes over time affect runoff. In "Sum of the Parts," students explore the concept, "We all live downstream." In "8-4-1, One For All," students demonstrate how water users share water resources. Finally, in "Make-a-Mural," students create a mural depicting their own watershed.

**Vocabulary**
mural, muralists, watershed, grid, thumbnail, basin, drainage, closed basin, pictographs, petroglyphs, graffiti

**Summary**
Students create a mural depicting various aspects of the watershed in which they live, including its landscape, people, cultures and plant and animal residents.

- Large wall that can be covered with paper
- Plastic or cloth sheet to be used as a drip cloth while students are painting
- Several step stools or sturdy chairs
- Newspapers or magazines to cut pictures from (optional)

**Part II**
- All supplies listed in Part I (except copies of Topic Cards)
- Straightedge and pencil for drawing guide lines
- Several large erasers

**Making Connections**
Students have likely heard the term "watershed," but may be unaware of all the elements of a watershed. They may only associate "watershed" with landforms. Students will understand that a watershed includes "all of the land, air, surface and ground water, plants and animals, mountains and deserts, cities and farms and people, including their stories and traditions." The term "watershed" will become more relevant as students discover and illustrate their own local watershed and its components.

**Materials**

**Part I**
- Copies of Topic Cards
- Long piece(s) of newsprint or butcher paper
- Assorted tempera paints, finger paints, water colors, crayons, markers, colored pencils
- Assorted paint brushes
- Empty egg cartons (to use as palettes)
- Kitchen sponges (to apply paint)
- Paper towels or strips of cloth (for cleanup)
- Empty coffee cans or plastic containers (to hold water for cleaning brushes and sponges)
- Packing tape
- Scissors
- Glue

**Background**
The mural is an ancient art form that has been employed throughout the world, including Asia, Europe, the Americas and Africa. Murals are large, bold paintings that depict myths, legends and visions of the future. Murals tell the story of the artist, the artist's community and the community's cultural heritage. Some murals may cover 2,500 square feet (225 m²) or more. The word mural is derived from the Latin word *murus*, meaning wall, but the use of murals has been
expanded far beyond walls. Artists from all over the world have created murals on walls and ceilings, rock, wood, animal skin, canvas and paper.

There are many ways to paint a mural. Some artists start in the center, working toward the outside corners as they progress. Others start in the corners, working methodically across the piece. Whichever method they prefer, the complexity of a mural dictates that it be carefully planned before work is started.

One planning technique employed by many artists uses a set of horizontal and vertical lines, known as a grid, to "map out" the mural. To make this map, the artist first creates a small sketch called a "thumbnail." A grid is then placed over the thumbnail and a corresponding one is made on the mural itself.

By matching the thumbnail grid with the larger grid, the artist can transfer the layout created in the thumbnail onto the mural. In addition, the artist may make a series of several hundred drawings to plan in detail the elements of the mural that have been roughed out in the thumbnail.

The planned structure of a mural may make the art form seem static, but this could not be further from the truth. Murals are dynamic and often symbolic—using images to address issues that are relevant to communities. Because of their large size, murals are created and displayed mostly in public places. This means that people of all social and economic groups may view the artwork. As a result, the mural has become a form of expression that allows individuals or groups to communicate their ideas to a broader audience.

Because of its large size and complexity, the mural is a perfect format for representing a watershed. A watershed, also called a basin or drainage, is an area of land drained by a river and its tributaries to a common outlet, which may be a closed basin, a larger stream, a lake, wetland, estuary or the ocean. (A closed basin is a water body from which water leaves only through evaporation or percolation; there is no surface outlet from this pond or depression, such as the Great Salt Lake in Utah.) Within its boundaries, a watershed includes all of the land, air, surface and ground water, plants and animals, mountains and deserts, cities and farms and people, including their culture, stories and traditions.

As murals worldwide have brought young people together for social and cultural unity, this format can be used to connect students with their local watershed. In addition to illustrating the physical boundaries of their watershed and its landforms, the plants and animals that live there and the people and their diverse cultures, a mural project can bring local water resource issues to the foreground.

(To view a mural online see: www.riveramural.org. This site is in Spanish and English and is an excellent example of a Diego Rivera mural.)

Lindsay Smith, a student at Aurora Alternative High School, details cave formations for a mural in Bloomington, Indiana.
**Procedure**

**Warm Up**

- Provide students the following abbreviated watershed definition:
  A watershed, also called a basin or drainage, is an area of land drained by a river and its tributaries to a common outlet, which may be a closed basin, a larger stream, a lake, wetland, estuary or the ocean. (A closed basin is a water body from which water leaves only through evaporation or percolation; there is no surface outlet from this pond or depression, such as the Great Salt Lake, Utah.)
- Ask students to name the components of a watershed (e.g., plants, animals, people, cities).
- When you have an exhaustive list, ask students in small groups to develop the definition of a watershed.
- Have students share their group definitions and work together to develop a class's definition.
- Read to them the complete definition of a watershed from the Background and compare it to the class's definition.
- Ask them if they know the name of their local watershed. If not, have them access Surf Your Watershed, http://cftp.epa.gov/surflocate/index.cfm.
- Based on the watershed categories they offered (Warm Up, bullet 2), have them list items in those categories relative to their watershed. For example, under the category "animals," have them list animals that live within their watershed.
- Tell students they will have the opportunity to further research their local watershed by producing a mural based on their knowledge of the watershed.

**The Activity**

**Part I**

1. Divide the class into equal groups of four to five students.
2. Distribute one or more topic cards from the Student Copy Page—Topic Cards to each group.
3. Have students research their topic(s) for their local watershed using notes from the Warm Up class discussion, books, the Internet, encyclopedias, interviews with experts, parents and so forth. In their groups, have them discuss their topics and how they will illustrate them in creating a mural.
4. On a long single piece of newsprint or butcher paper (long enough to stretch from one end of the classroom to the other), have a few students color, from left to right, a serpentine blue line representing the main stem of their watershed. The line—perhaps one to two inches (2.5 to 5 cm) wide—should be wide enough to be seen at a distance.
5. Cut the single sheet of newsprint or butcher paper into shorter segments equal to the number of groups you designate, and mark the corners so that they can be matched later. Give each group one of the segments.

**Part II**

1. Have the class decide which issues they would like to address in their mural project.
2. Have students research issues in which they are most interested and create a rough sketch.
3. Have the class come together again to determine how they will depict their subjects and to create a "thumbnail" (visual outline) of the mural. The thumbnail does not have to be too detailed, but it should create a blueprint of the mural.
4. Have a few students connect several sheets of butcher paper using packing tape. The resulting sheet should be large enough to cover the wall on which the work will be displayed.
5. Turn the large sheet over so the tape is on the back. Have the students use a straightedge to lightly draw straight vertical and horizontal grid lines on the large sheet, spacing the lines exactly six inches apart.
6. Draw grid lines on the thumbnail of the mural, making sure there are exactly as many equally spaced vertical and horizontal lines as there are on the large sheet. The lines will be used as aids in transferring the layout of the thumbnail to the mural on the wall.

7. Have a few students hang the large sheet on the wall.

8. Tape the drip cloth to the floor below and around the mural.

9. Make copies of the thumbnail and hang them on either side of the large sheet. To ensure that they are not deviating too far from their planned mural, encourage students to refer to the thumbnail often.

10. Using paint, markers, pencils and magazine clippings, have students create the mural. Grid lines should be erased as the students fill in the blank sheet.

11. Have students present their mural to other classes, explaining the symbolism and analyzing their selected issues.

Wrap Up

* In Part 1, the main stem of the river is the obvious line of continuity from segment to segment. Are there others? What are they?

* Ask students to compare and contrast mural segments. What are the similarities and the differences? Did groups choose different media? Why? How effective were they in conveying the landscape, plants, animals, people, their celebrations and so forth? Are the artistic styles different? How do they vary?

* Discuss the diversity of art styles and interpretations of the watershed by different groups. Have students relate this to the diversity of people, cultures and art within the watershed. How are they related?

* Did student muralists encounter difficulties in translating their assigned topic(s) onto the mural?

* Ask students to consider how difficult it would be and how long it might take to paint a larger and more complex mural. What if they were lying on their backs like Michelangelo did when he painted the ceiling of the Sistine Chapel in Rome?

* Are the prehistoric artworks of indigenous peoples (cave paintings, cliff side galleries of pictographs or petroglyphs) similar to modern murals?

* What about walls covered with graffiti? What separates graffiti from art? List the differences and the similarities.

Project WET Reading Corner


Learn about the biodiversity that can be found in temperate (cooler) forests of the world.


By studying watersheds, students develop research skills and integrate these in a relevant way.


This book addresses the geography, geology, climate, life, biodiversity, ecology, people, uses, threats and management of some of Earth’s largest freshwater biomes.


This book introduces the concepts of watersheds and progresses to wetland ecosystems and ecology.


This how-to book gives tips for painting murals.


A wonderful interdisciplinary book exposing students to the broad range of aquatic environments found on Earth.


Learn about the biodiversity that can be found in agricultural and urban areas.


Through this book, watersheds come to life, and kids also discover how to help protect the many types of life that live in these special habitats.


Janisse Ray writes about her childhood in southern Georgia growing up amidst the long leaf pine forests and strives to educate people to connect with and preserve their local environment.


Readers follow Ann Morgan (early 20th century naturalist) as she uncovers the mysteries of life in a pond.


The author takes us back to his childhood memories of the Chesapeake, and, as a scientist, shares his knowledge of the area and of ways to use it wisely.
**Assessment**

Have students:
- develop a definition of “watershed” and compare it to a formal definition (*Warm Up*).
- identify their own watershed through an Internet search (*Warm Up*).
- research the natural and human elements of their local watershed (*Part I*, step 3).
- illustrate the results of their research by producing a mural (*Part I*, step 6).
- research water resource issues in their local watershed (*Part II*, steps 1-2).
- organize the layout of a mural (*Part II*, steps 3, 5 and 6).
- use teamwork to create a mural that illustrates the results of their research and planning (*Part II*, step 10).
- make an analytical presentation of their mural (*Part II*, step 11).
- apply the diversity of art styles and interpretations in the mural to the diversity of people, cultures and art in the watershed (*Wrap Up*).

**Extensions**

Ask students to write short essays or journal entries interpreting their mural(s).

Suggest that students, with their parents, tour their city searching for murals and taking pictures of the ones they find. They can develop a Google Earth Tour or a blog documenting their mural city tour.

Use this activity to assess student learning. Change the Topic Cards (*Part I*) to reflect concepts about which you wish to assess learning.

**Teacher Resources**

**Books**


**Journals**


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*This 11-by-4-foot mural depicting drainage above and below ground, in both natural and man-made systems, decorates a blackboard area at the Bloomington Parks and Recreation’s Banneker Community Center in Bloomington, Indiana.*
Directions: Research all topics for the watershed in which you live.

<table>
<thead>
<tr>
<th>Water Features</th>
<th>Architecture</th>
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<tbody>
<tr>
<td>(e.g., Waterfalls, Lakes, Rivers)</td>
<td>YOUR WATERSHED!</td>
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<table>
<thead>
<tr>
<th>Geologic Features</th>
<th>Arts and Crafts</th>
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<tbody>
<tr>
<td>(e.g., Mountains, Canyons, Sand Dunes)</td>
<td>YOUR WATERSHED!</td>
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<tr>
<th>Plants</th>
<th>Celebrations</th>
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<tr>
<td></td>
<td>(e.g., Music, Food)</td>
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<table>
<thead>
<tr>
<th>Animals</th>
<th>Historic Events</th>
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<tr>
<td></td>
<td>YOUR WATERSHED!</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>People</th>
<th>Human Activities</th>
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</thead>
<tbody>
<tr>
<td>(e.g., Past and Present, Different Cultures and Occupations)</td>
<td>(e.g., Farming, Manufacturing, Recreation)</td>
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<table>
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<tr>
<th></th>
<th>YOUR WATERSHED!</th>
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</table>
**What's Been Polluting the Ground Water?**

**Background Information**

The term *soil* refers to the thin outer layer of the earth's surface that consists of disintegrated and decomposed rock material and the accumulated residues of plant and animal life. In essence, soil is made up of four basic components: Minerals, organic matter, water, and air. The soil layer, which varies in thickness and composition from place to place, is a living "blanket" that overlays subsurface bedrock and supports life. Indeed, soil is the earth's medium for plant growth; it is home to a multitude of organisms, such as earth worms, insects, and soil bacteria; and it is the mainstay of our homes, businesses, and highways.

Soil is also an excellent filter; it has the capacity to remove pollutants from water through intrinsic physical, chemical, and biological processes. For millions and millions of years, soil has played an important role in keeping the earth's finite, recycled water supply clean. However, even soil has its limits. Some kinds of pollutants can't be filtered out. For example, some pesticides are not readily biodegradable and persist in soil and ground water for many years. Some hazardous substances may actually be leached (dissolved and carried along) with water as it soaks into the ground.

When pollutants leak, spill, or are carelessly discarded into and onto the ground, they, like water, move slowly or quickly through the soil, depending on the soil, the nature of the pollutant, and the amount of extra help they get from incoming precipitation. How effectively pollutants are filtered by soil depends on such factors as the type of pollutant, the soil type, and the soil depth.

In general, because ground water is located deep in the ground, polluted ground water is difficult and expensive to clean up. In some cases, people have had to find alternative sources of water because their own wells were contaminated.
WHAT'S BEEN POLLUTING THE GROUND WATER?

and unsafe for drinking. Thus, the best solution to ground water contamination is protection and prevention.

TEACHING STRATEGY

Note: This activity builds on the previous activity, "Can Dirt Make Water Clean?"

1. Divide students into teams of 3-4. Distribute copies of the handouts, including data sheets. Read the scenario together. Explain that some pollutants that are on the surface of the soil or mixed in with the soil can be leached (dissolved and carried along) as the water slowly soaks into the ground and moves into the ground water.

2. Have each team construct its own ground water model. If the base of the soda bottle is not clear, have students use a beaker as a stand to support the soda bottle so that they can see the water after it filters through the soil. (See diagrams on pages C18 and C19.)

3. Make sure students read the entire experiment and formulate a hypothesis before beginning the experiment.

4. As students add pollutants to the soil, encourage them to use the rain cups so that the water is spread evenly and flows through the soil slowly.

5. Tell students to fill in the results section of their data sheets as they go along.

6. Students should notice a cumulative effect as more and more pollutants contaminate the ground water.
WHAT'S BEEN POLLUTING THE GROUND WATER?

Scenario:
Mr. and Mrs. Public have been confident that the water in their ground water well is of excellent quality. They know that soil is an excellent filter. As water flows through the soil, many contaminants are left behind and cling, or adsorb, to the soil particles.

But lately Mr. and Mrs. Public have begun to worry that perhaps some contaminants are being dissolved and carried along as the water slowly soaks into the ground and becomes part of the ground water. They have asked the water detectives to perform an experiment to find out how good a filter the soil really is.

Step 1: Read the following experiment all the way through.

Step 2: State your hypothesis: (Make a prediction about what you think will happen before you do the experiment.) For each “pollutant,” write the name of the pollutant and state your hypothesis on the Water Detective Data Sheet. What do you think the water will look like after it passes through the various contaminants in the ground water model?

Step 3: Perform the experiment.

<table>
<thead>
<tr>
<th>Materials</th>
</tr>
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<tbody>
<tr>
<td>☐ Clear plastic soda bottle</td>
</tr>
<tr>
<td>☐ Pieces of old nylon stockings or tights</td>
</tr>
<tr>
<td>☐ Rubber band</td>
</tr>
<tr>
<td>☐ Clean gravel</td>
</tr>
<tr>
<td>☐ Clean sand</td>
</tr>
<tr>
<td>☐ Water</td>
</tr>
<tr>
<td>☐ Beakers</td>
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<tr>
<td>☐ Measuring spoons</td>
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<tr>
<td>☐ “Rain cups” - Paper cups with holes punched in the bottom</td>
</tr>
<tr>
<td>☐ 1 eyedropper per team-to add food coloring</td>
</tr>
<tr>
<td>☐ “Pollutants”</td>
</tr>
<tr>
<td>☐ Table salt (2 Tbs.) - represents road salt, which may dissolve in snow or rain and get into the ground water</td>
</tr>
<tr>
<td>☐ Red food coloring (5-20 drops) - represents hazardous or toxic materials</td>
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<tr>
<td>☐ Vegetable oil (2 tbs.) - represents motor oil</td>
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<tr>
<td>☐ Paper towels soaked in 1/4 cup of water and 5 drops of blue food coloring - represents contaminants in garbage at landfills, which can leach into the ground water</td>
</tr>
<tr>
<td>☐ Baking soda (2 tbs.) - represents commercial fertilizer</td>
</tr>
<tr>
<td>☐ Vinegar (2 tbs.) - represents household chemicals</td>
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</tbody>
</table>
**Directions:**

1. Make a ground water model:
   
   A. Cut 6 inches off the bottom of several plastic soda bottles as shown in illustration. Use the bottom of the bottle (if clear) as a stand.
   
   B. Cover the necks of the bottles with pieces of nylon stockings or tights. Secure them tightly with rubber bands.
   
   C. Invert the tops of the bottles into the stands (bottom halves of the bottles) as shown in the illustration, or use a beaker as a stand instead.
   
   D. Put a 2-inch layer of coarse sand, and a 2-inch layer of gravel into the inverted top of one soda bottle.

2. Place each of the "pollutants" on the top of the soil in the ground water model one at a time. (The materials listed above are not harmful to you. However, they are being used to represent harmful substances.)

3. *Slowly* pour water through the "rain cup" and on to the surface of the soil. (This represents rain.)

4. Pour the rain water until it begins to fall into the clear beaker at the bottom of the ground water model.

5. Did the "polluted" water look cleaner after it was poured through the model? Note any changes in color and smell. Record your observations on the data sheet provided.

6. Repeat steps with other "pollutants."
Conclusions:

1. Did the sand and gravel help to filter out some of the pollutants? __________
   Give examples. ____________________________________________

2. Did some of the pollutants get through the sand and gravel? __________
   Give examples. ____________________________________________

3. Were there pollutants which you were unsure about, regarding whether or
   not pollutants had been filtered out? If so, what other means might you use,
   besides sight or smell, to determine their presence? ________________
   As you added more and more pollutants to the soil surface, how was the
   quality of the water affected? __________________________________

4. How did your results compare with your hypotheses? ________________

Hint: After performing this experiment, the water detectives told Mr. and
Mrs. Public that the best way to keep ground water protected from pollu-
tants is to make sure that pollutants don't get into the soil in the first place.
## Water Detective Data Sheet

<table>
<thead>
<tr>
<th>&quot;Pollutant&quot;</th>
<th>Hypothesis</th>
<th>Actual Results</th>
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RUN OFF EXPERIMENT
FOR
BOTTLE BIOLOGY TERRAQUA COLUMN

Follow steps 1-3 on page 62, the directions to make a terraqua column, also called a TAC. Make 2-7 number of TAC’s

Step 4: Use a nail heated over a candle and held with a pliers to melt a number of small holes into the cap.

Fill the bottom of part C with clean gravel and add non-chlorinated water to about the 3/4ths level.

Place in water plants such as elodea, anacharis, or duckweed, and animals such as pond snails. I don’t recommend using vertebrates such as fish since they may die in this experiment.

Let the lake model set for a couple of days to make sure it is OK.

Assemble the TAC as shown in step 5 of the directions. NOTE use a paper punch to put a number of holes all around the bottom of part B. These holes need to be high enough not to be covered by part C when the TAC is assembled.

Fill the neck of part A with large gravel, then a layer of small gravel, followed by a layer of sand. Fill the rest of part A with potting soil just like you would if it was a flower pot at home.

Plant grass seed in the potting soil. You can water all your TAC’s with plain tap water until the grass germinates, is well established, or start the experiment now.

Into separate squirt bottles, or other 2 liter bottles, mix up a number of different concentrations of liquid plant fertilizer. For a class with 10 groups I suggest 2 plain water, 2, 1/2 the recommended rate, 2 full strength; two, 1 1/2 the recommended strength, and one twice the recommended amount. (I have two groups do the same thing just in case one of the TAC’s is dropped, spills, etc. This way you still have some results)

Have each group use one concentration to water the grass in their TAC as needed. Promote over watering as the extra water will run down through the soil and cap and fall into the pond. This simulates the effect lawn or farm fertilization has on lakes in those areas.

Monitor the TAC’s, measuring or observing both the land and the pond environments for a number of weeks. Please note some snails may die. Especially if you use any kind of fertilizer that contains weed or insect killer. This may be a concern to some students and / or their parents.
1. Remove labels from the two bottles. Remove base from one bottle, if they both have separable bases (see Bottle Basics p. 3).

2. Cut the bottle with no base, 6-7 cm below shoulder curve, leaving a straight end on cylinder B.

Cut off the bottom 1-2 cm below hip curve, leaving a tapered end on cylinder B.

3. Cut top off second bottle 2 cm below shoulder, leaving a straight end on piece C.

4. Punch or drill a hole in cap with an awl or drill. It is very important to enlarge the hole with a tapered reamer or drill bit to about 1 cm wide, enough to easily accommodate the wick. Attach cap to A.

5. Invert top A into cylinder B. Tape this joint for stability. Slide A/B unit into C.

6. For wick, cut a strip of fabric interfacing 1-2 cm wide and slightly shorter than the height of the column. Insert a wet wick as shown.

When adding soil, make sure the wick runs up into the soil and is not plastered along the sides of the column or protruding above the soil surface. After you fill the column you may want to tape B and C together.
What goes in a TAC?: The basic components of the TerrAqua Column are soil, water and plants. How do these components interact in a TerrAqua system? (The word system indicates you are dealing with a diversity of organisms and the interactions between them.)

Plants growing in the upper part of the TAC take nutrients from the surrounding soil and, with the aid of the wick, take water and other substances from the aquatic portion below. Substances you add to the terrestrial section will move down, or percolate, through the soil and drain into the aquatic section.

How do land and water interact in your area?: Does runoff from fertilized lawns or agriculture threaten the quality of your streams or groundwater? Is salt pollution a problem, from either road salt, irrigation, or saltwater intrusion? Are landfills affecting local groundwater?

Soil, water, and plants: Fill the top unit of your TAC with soil you collect, or with potting soil from a gardening store. Fill the lower aquatic unit with tap water, or water from a pond, lake, puddle or fish tank.

Collected soil and water will likely contain algae, phytoplankton, plant seeds and insect larvae. Store-bought soil and tap water will include far fewer organisms. (To observe this, fill one TAC with soil and water from nearby woods or park and another with potting soil from a garden store and tap water. Set them side by side and observe for several weeks. For more on soil life, refer to "Soil Meditations," p. 33.)

Terrestrial and aquatic plants are excellent indicators of change in your system. Fast-germinating and fast-growing plants will most effectively register change in a short period of time.

Grasses, particularly lawn seed mixes, work well. Prairie grasses grow more slowly but have deep roots that are interesting to observe. Radishes and beans also work well, though you will need to soak dried beans overnight before planting. Wisconsin Fast Plants, which have been developed to complete their life cycle in 35-40 days, are ideal candidates for experimentation in TACs (see p. 8).
What do you see?

Ask a question

Talk to others about your experiment

Suggest an answer

Did you answer your question?

MY HYPOTHESIS: Garlic is an effective fertilizer

Design an experiment

SCIENCE EXPLORATION MAP
A simple model, a complex world: The TAC, a relatively simple model, allows you to focus on specific aspects of a complex world. Imagine, for example, a lake near your house that is suddenly overtaken with algae.

Given all the environmental factors that influence the lake, you would be hard pressed to determine exactly which factors encouraged the slimy green stuff to get out of control.

You could build several TACs in order to explore specific factors that might encourage algae. Try taking samples of lake water and local soil, for example, and then testing them under different conditions to see in what sorts of environments algae grows best.

Your observations and experiments can go in many directions, so the clearer you are in defining your question and designing your experiment, the more successful your experiment will be.

Variables: Variables to consider in your experiments include:

- The type and amounts of soil, water, and plants - remember, depending on their source, the soil and water will likely contain such life as algae, fungus, mites, Daphnia, etc.

- Substances that might affect terrestrial and aquatic systems - nutrients (fertilizers), or pollutants (salts, pesticides, acids).

- A treatment plan - once you have decided on a substance to test you can apply different amounts of that substance; treat only the terrestrial chamber; treat only the water reservoir; apply it directly to plant leaves; test it on plants of various ages, or vary the treatment schedule.

- Physical factors - temperature, light, sound, etc. (Try singing or screaming at your plants. One student grew Wisconsin Fast Plants to the tunes of Bach, Barry Manilow and Heavy Metal — Barry Manilow encouraged the most growth!!)
**Indicators:** Indicators in a TAC are plants and animals and other system characteristics that change in response to your experiments, giving you information regarding your hypothesis. Indicators include terrestrial and aquatic plants and the pH of soil and water.

Some observations you can make of a plant indicator, for example, include percentage of seeds that germinate, plant height and weight, leaf size and shape, root structure, number of flowers, length of life cycle and seed production. In the aquatic system, indicators include increases or decreases in populations of algae and duckweed. These changes can show up as cloudiness in the water. You can also use the bioassay to determine the effects of a substance on plants (see p. 93).

**Controls:** With every experiment you run, set up one control TAC in which you do not vary any of the components. This acts as a standard against which you can compare the effects of variables you do change.

**Keep it simple:** The TAC is a simple model, but all of its parts are dynamic. Keep your investigations very simple by changing only one variable of the system at a time.

Some of the more often investigated substances include fertilizer, pesticides, acid "rain" and oil. A detailed example of a salt pollution experiment follows; you can also use the procedure to investigate other substances.
In this section of Water1der, students will learn about conserving groundwater.

Some concepts to discuss prior to this section include:

15. We use a lot of water in the United States. A family of four uses 400 gallons of water EVERY DAY in the United States. You could take 11 baths with 400 gallons of water!

16. Less than 1% of all the water on Earth is usable, so as our population grows more and more people are using this limited resource.

17. If we take out more water from the aquifer than is being put back in depletion occurs. When depletion occurs, there is less water to take out of the aquifer.

18. Below are some ways you can help conserve this limited resource!

- Turn off the tap while brushing your teeth. (Saves up to 8 gallons a day!)
- Take a shower rather than filling up a bathtub. (A shower takes about 30 gallons and a bath takes over 36 gallons!)
- Water your lawn in the early morning or late evening when it’s cool outside. The water evaporates less so the plants can drink it.
- Wash your bike or car with a bucket and sponge instead of a hose. (Saves up to 6 gallons per minute!)
Questions and Answers

Conservation

3. How much water does an acre of corn give off per day in evaporation in gallons?
   • 6,700
   • 5,200
   A. 4,000
   12. 1,700
   13. 850
   14. 0

11. What happens when more water is taken out of an aquifer than is put back in?

   • Runoff
   A. Depletion
   3. Flooding
   4. Saturated

12. If a well reaches groundwater, an unlimited amount of water can be pumped. True or false?
   φ True
   False

4. How much water does it take to:
   φ Take a five-minute shower?
   φ Brush your teeth with the water off?
   φ Take a full-sized bath?
Questions and Answers

Conservation

4. How much water does an acre of corn give off per day in evaporation in gallons? • 6,700 • 5,200

A. 4,000

15. 1,700
16. 850
17. 0

12. What happens when more water is taken out of an aquifer than is put back in? • Runoff

A. Depletion

5. Flooding
6. Saturated
13. If a well reaches groundwater, an unlimited amount of water can be pumped. True or false?

φ True

4. How much water does it take to:

φ Take a five-minute shower? 30 gallons
φ Brush your teeth with the water off? Less than one gallon
φ Take a full-sized bath? 36 gallons
REFERENCES


Vermeersch, T. (2016). *How do we educate children that live in a water rich environment about the need for water conservation?* School of Education Student Capstones and, School of Education, & Dissertations. (b). DigitalCommons@Hamline