

# INTRODUCTION TO ECOLOGY

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Ecology deals with the relationships living things have with each other and with their environments (surroundings). Scientists who specialize in studying these relationships are called ecologists.

No living thing—plant or animal—lives alone. Every living thing depends in some way on certain other living and nonliving things. Animals and plants that live in the same area, or community, depend on each other in some way. For example, an elephant must have plants for food. If the plants in its environment were destroyed, the elephant would have to move to another area that had plants, or it would starve to death. Plants depend on such animals as the elephants for the nutrients (nourishing substances) they need to survive. Animal wastes and the decaying bodies of dead animals and plants provide many of the nutrients that plants need.

The study of ecology increases people's understanding of the world and all its creatures. This is important because humanity's survival and well-being depend on relationships that exist on a worldwide basis. Change in distant parts of the world—even outer space—affect us and our environments.

One goal of ecologists is to intelligently manage and control the living and nonliving things in the world. Many ecologists study air and water pollution and how dirty air and water affect life. Ecologists try to foresee possible environmental problems, such as crop losses or losses in animal life that building a dam or straightening a river channel may cause. They study such things as insect pests, including the beetle that carried the Dutch elm disease from Europe to the United States where it killed millions of trees.

Ecologists are concerned about the rate at which people are using up such natural resources as coal, gas, and oil. Along with many other scientists, they are searching for ways to use sunlight and atomic energy for fuel and power. Ecologists also are concerned about the world's increasing population and its decreasing food supply. For example, along with marine biologists, they are trying to find new ways of producing food from the sea.

Ecologists use knowledge from many different fields of study including physics, chemistry, mathematics, and computer science. They also rely on other sciences, such as climatology, meteorology, geology, and oceanography, to learn about air, land, and water environments.

Adapted from *World Book Encyclopedia*



# Deer Populations and Carrying Capacity

## OBJECTIVES:

Students will be able to:

1. Calculate expected increases in population of a deer population in the absence of predation.
2. Prepare bar and line graphs of population growth.
3. Explain how a deer population is adapted to heavy predation.
4. Describe how unchecked population growth affects carrying capacity.

## BACKGROUND:

Deer have survived on the North American continent for millions of years. As the vast virgin hardwood forests of the 16th century were cleared and farmed by early settlers, the deer population probably increased as edge habitat with browse plants increased. Certainly deer were plentiful by all accounts in the mid 1800s. However, by 1900, unrestricted year-round hunting and loss of habitat had reduced the number of deer in Alabama to very low levels. State laws were passed for protection of wildlife but couldn't be enforced because of lack of public support. Finally, large landowners interested in conservation and U.S. Forest Service officials began buying and releasing deer from other states to restock Alabama lands. It has been estimated that current deer populations exceed one million. For every deer in Alabama in 1935, we now have 70.

Deer are prolific breeders. A population of deer in an uncrowded habitat is capable of doubling itself within two years. This was adaptive behavior when deer were subjected to high predation by coyotes, wolves, bears, and bobcats, but is not now an advantage since people have displaced most of the deer's normal predators. When carrying capacity is exceeded, deer get smaller, become more susceptible to disease, suffer health problems associated with malnutrition, and may starve or may encroach into populated areas with crops and gardens. Sometimes, as on the Kaibab Plateau in Arizona after all predators were removed, a population will exceed the carrying capacity to the point that the population will "crash," decimating the herd and requiring 20 years or so to rebuild a healthy herd.

Management of deer populations usually includes regulated hunting. For every 100 deer in Alabama, the normal sex (bucks=male; does=female) and age ratios are:

- 5 bucks, age 1+ yr., 3 or more points (antlers)
- 10 bucks, age 1+ yr., spikes visible above hairline
- 5 bucks, age 1+ yr., no visible spikes
- 20 bucks (fawns), age <1 yr.
- 40 does, age 1+ yr.
- 20 does (fawns), age <1 yr.

With a bucks-only hunting season, only 15 of 100 deer can legally be hunted. Typically, only a third are actually killed, a loss that doesn't harm the population. It also doesn't address the problem of 40 does each usually having 2 more fawns each year.

## VOCABULARY:

edge habitat, browse, carrying capacity, predation, bucks, does, fawns

### Grades:

9-12

### Subjects:

Biology, Ecology, Math

### Time Needed:

One class period (50-60 minutes)

### Materials:

graph paper  
calculators  
colored pencils  
rulers  
teacher handouts

## ADVANCE PREPARATION:

1. Gather enough graph paper for the students. If they are allowed to use calculators, remind them to bring the calculators to class.

## PROCEDURE:

### *Setting the Stage*

1. Determine what the students know about white-tailed deer. Question them about such things as life cycle, life span, habitat, predators. Don't give much information at this point.
2. Take an informal poll to see how the students feel about hunting.
3. Review bar graphs and line graphs.

### *Activity*

1. Read aloud the following scenario:  
There is a herd of deer in a protected area with no hunting allowed. The site has wooded areas and also areas that are filling in after having been previously cleared and farmed. There is a creek on the property, not large but flowing throughout the year. The area is fenced around its perimeter, but access roads allow some passage in and out. The only predators are an occasional coyote and small packs of dogs.
2. If the area has a carrying capacity of 250 deer, how long would it take to reach carrying capacity if the area initially had 50 deer?
3. Let students write down their predictions.
4. Tell them they're going to track the population in this herd over the next 10 years. Write the following assumptions on the board and then read them aloud to the students:
  - Of the 50 deer, half are female.
  - All of the deer are two years old. Female deer are sexually mature at one year. Males are sexually mature between 1.5 and 2.0 years. Assume 1.5 fawns per year for all does older than 1 year.
  - Does have 1 fawn in their first breeding season and 2 fawns per year thereafter.
  - Predators have a minimal impact. Deer evolved in the presence of more predators and more *kinds* of predators than they now face.
  - The deer die at age 10, not unreasonable in a protected habitat with ample food.
5. Make a bar graph for the 10 years. Each year should have a line for (1) beginning number (for that year); (2) number of does; (3) number of new fawns; (4) new total.

### Example:

Year #1 starts with 50 deer. The 25 does have 37 fawns ( $25 \times 1.5$ ) and there are 25 bucks for a total of 87 deer at the end of the year.

Year #2 starts with 87 deer. The 43 does have 64 fawns and there are 43 bucks for a total of 150 deer at the end of the second year.

Year #3 starts with 150 deer. The 75 does have 112 fawns and there are 75 bucks for a total of 262 deer at the end of the third year. The herd reached carrying capacity at the end of three years.

\* Students do not have to receive all the examples; this is for you. Just let them figure from year to year until they reach carrying capacity. Then have them complete the exercise for the 10-year span, although probably something would intervene to reduce the herd before that time (starvation, disease).

6. Make a line graph to also cover the 10 years.

### *Follow-Up*

1. Ask the students to speculate on why deer have such high reproductive rates. Under what conditions would this be a good or necessary adaptation? What has changed?
2. Deer management officials say that since people's activities and loss of habitat have removed most of the deer's natural predators, it is up to us to manage their numbers to maintain healthy populations. Short of bringing back wolves, coyotes, bobcats, and bears; awarding bonus points for turning deer into roadkill;

capturing and sterilizing deer in great numbers or allowing regulated hunting, what can we do? Brainstorm possible solutions.

3. See if opinions about regulated hunting have changed.

### **EXTENSIONS:**

1. Redo the graphs with a reduced reproduction rate of 1 fawn per doe per year.
2. Redo the graphs with various percentages of loss due to predation or hunting. What percentage of loss each year would be required to maintain a stable population?
3. Review the hunting laws of Alabama available at [www.dcnr.state.al.us](http://www.dcnr.state.al.us). Make recommendations that might alleviate the overpopulation problem.

### **ORIGINAL DEVELOPMENT RESOURCES:**

Gwin, G. (1996, Spring). The Place Alabama's Wildlife Calls Home. *Outdoor Alabama*, 4-11.

[www.dcnr.state.al.us](http://www.dcnr.state.al.us)

[www.buckmasters.com](http://www.buckmasters.com)

### **ADDITIONAL RESOURCES:**

Smithsonian North American Mammals: [www.mnh.si.edu/mna](http://www.mnh.si.edu/mna)

Outdoor Alabama: [www.outdooralabama.com/watchable-wildlife/Mammals/Ungulates/](http://www.outdooralabama.com/watchable-wildlife/Mammals/Ungulates/)

# Notes

# Over Hill, Over Dale, Over Plants, Over Animals

## OBJECTIVES:

Students will be able to:

1. Define and identify the impacts of Off Road Vehicles (ORVs).
2. Compare the positions of groups involved with and impacted by, ORVs.
3. Defend a position, whether or not it is the student's own personal one.
4. Compare the issue of rights of the individual versus the rights of society.

## BACKGROUND:

Ownership and enjoyment of Off Road Vehicles (ORVs), as well as environmental issues, are very popular with teenagers. This activity will help them understand the impact of this recreational activity on the soil, water, and wildlife. It also will explore the concerns of different involved groups.

## VOCABULARY:

Off Road Vehicles, erosion, silt/sediment/watershed, degradation

## PROCEDURE:

### *Setting the Stage*

1. Photograph popular ORV locations in the area and bring them to class. Keep any identifiable signs out of the picture.
2. Show the pictures and discuss the environmental impacts such as compacted soil, runoff, and resultant destruction of habitat.
3. Ask the students to identify what could have caused this damage and where the pictures were taken.

### *Activity*

1. Divide the class into three investigative teams and give each team a team assignment sheet (See "Over Hill, Over Dale" sheet). Allow time to brainstorm the areas that need filling in on this sheet.
2. Monitor the teams' work and give approval before proceeding to the next step.
3. Students are to carry out investigations.
4. Using any approved method, they are to present the information to the class.

### *Follow-Up*

1. Explain how to use a Futures Wheel. See accompanying information.
2. Divide the class into small groups. Give each group a blank Futures Wheel and let them fill it in. It is best if the groups are separated so that students cannot hear what is being suggested by other groups.
3. Let each group share its wheel and follow this with a discussion of a possible solution. It is not necessary to reach a consensus.

## EVALUATIONS:

1. Grades will be based on the evidence of research, following assignment requirements, quality of presentation, and participation in class assignments.
2. Students will turn in an individually completed position paper on the rights of the individual versus the rights of society using ORV as an example. This is a graded assignment.

## Grades:

9-12

## Subjects:

Environmental Science, Science, Social Studies, Art

## Time Needed:

One class period for the presentation; time for research, some class time and some individual

## Materials:

Over Hill, Over Dale, Team activity sheet  
Using a Futures Wheel (2 pages) activity sheets

## **EXTENSIONS:**

1. Divide students into two groups. Have one group develop a Bill of Rights for ORV users and the other group develop a Bill of Rights for watershed citizens impacted by ORVs. Compare and contrast the two statements.
2. Obtain information about the Tread Lightly environmental program for 4x4s available at [www.treadlightly.org](http://www.treadlightly.org) or 1-800-966-9900..
3. Have students develop an educational bulletin board for ORV users and display it somewhere in the school.

## **ORIGINAL DEVELOPMENT RESOURCES:**

ORV user magazines and groups

*Science Scope*, January, (1994). pages 18-19.

## **ADDITIONAL RESOURCES:**

<http://www.fort.usgs.gov/products/publications/22021/22021.pdf>

<http://www.wildlandscpr.org/road-riporter/environmental-impacts-road-vehicle-races-and-events-literature-review>

## Over Hill, Over Dale

	<b>Team 1</b>	<b>Team 2</b>	<b>Team 3</b>
<b>Group To Investigate</b>	<i>ORV Users</i>	<i>Concerned Environmental Groups</i>	<i>Governmental Bodies/Agenies</i>
<b>Information Needed</b>			
<b>Methods Used to Obtain Information</b>			
<b>Presentation Plans</b>			

## Using A Futures Wheel\*

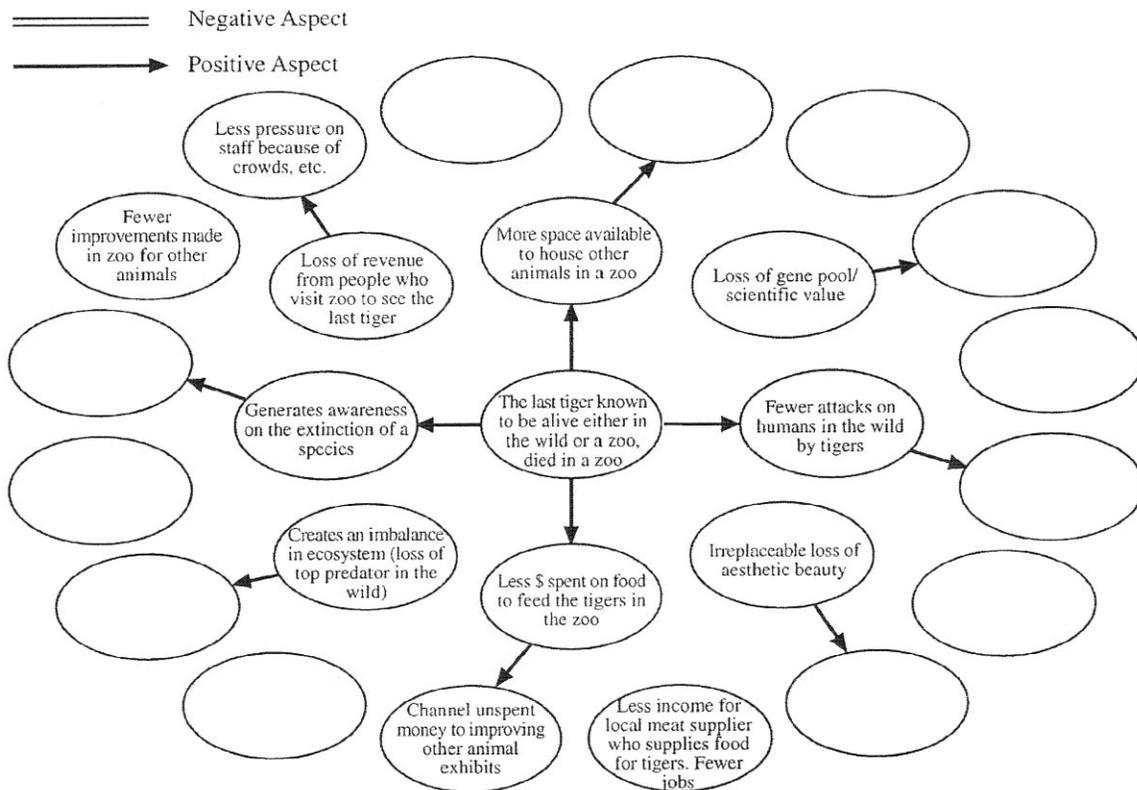
**Time:** Students need about 20-25 minutes to complete the wheel and additional time for class discussion. Monitor their progress the first few times. Once this method becomes familiar to them, it can be used for any issue without much teacher intervention.

A futures wheel is a graphic toll to assist students with productive brainstorming. Using the wheel guides students in seeking both sides to issues and helps them to “see” where their thinking is progressing.

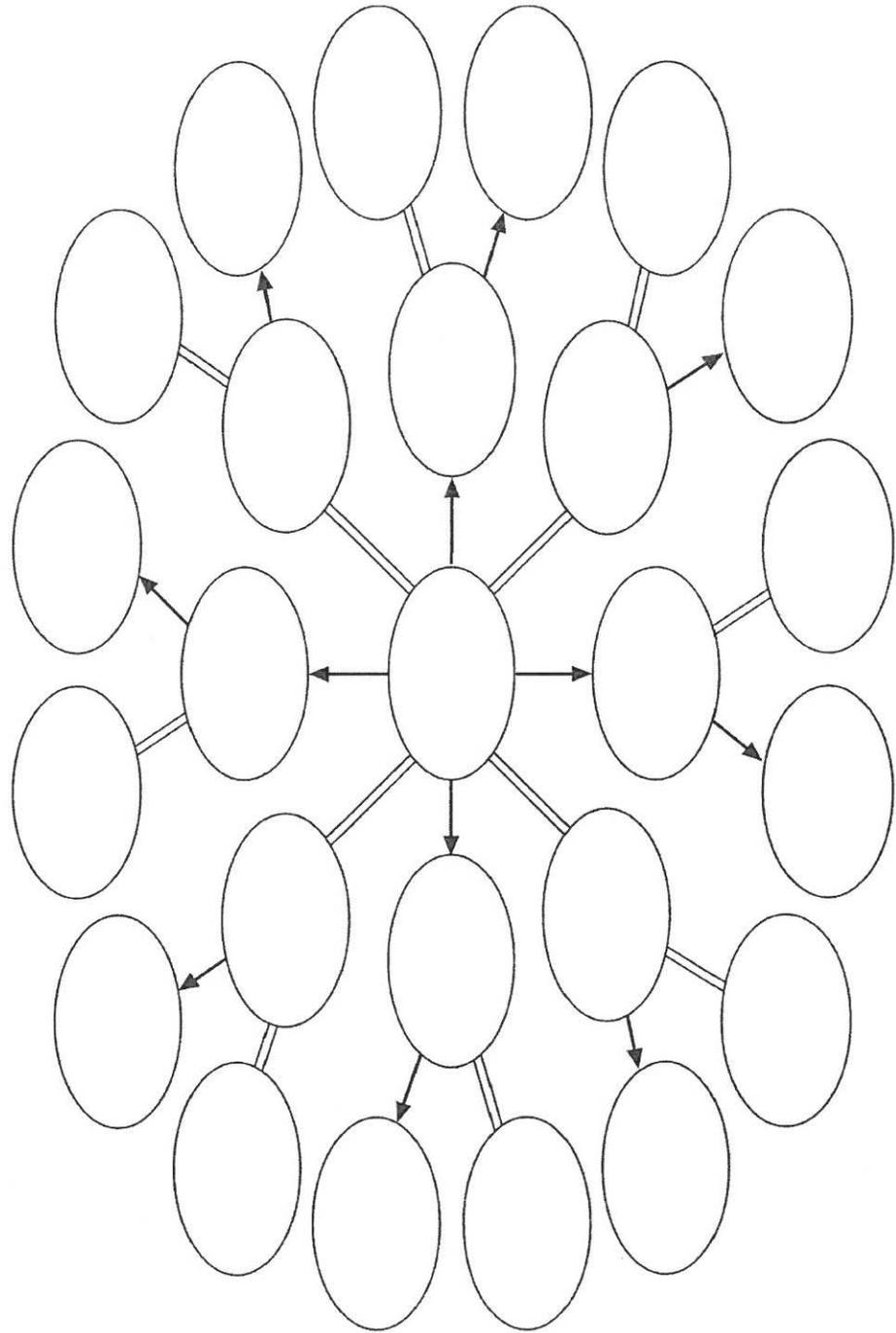
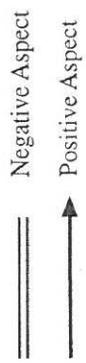
Directions: Divide students into very small groups (three to four is best) and give each groups a blank futures wheel. In the center oval have them write the problem they are trying to solve. In each of the closest surrounding ovals connected with an arrow, they are to add (after discussion within their group) four positive aspects of this problem. In each of the closest surrounding ovals connected with a double line, they are to add (after discussion within their group) four negative aspects of the problem. Next, following the same pattern, they are to complete each of the additional ovals. Remind the students that they must address the statement in the closest adjoining oval, not return to the center each time. Also, once a response has been agreed upon by the group, it should not be changed even when it is hard to think of a corresponding response. Forcing critical and open-minded thinking is the value of using the wheel.

\*Adapted from: Puls, Dan and O’Brien Pamela. “What’s a Zoo to do?” *Science Scope*, January, 1994. p 17-20

### Futures Wheel Example



# Futures Wheel



# Notes

## OBJECTIVES:

Students will be able to:

1. Research the Life Cycle Assessment (LCA) of certain market items.
2. Compare the LCAs of Europe with those of Alabama.

## BACKGROUND:

All products have environmental impacts over the course of their existence from extraction/procurement of raw material to manufacturing, distribution, use, and disposal. Life Cycle Assessment (LCA) is a holistic evaluation of all direct and indirect, pre-market and post-market, and recycle/disposal aspects of a product. Other names for Life Cycle Assessment are ecobalance, cradle-to-grave analysis, and environmental profile analysis.

Determinations of what is environmentally preferable are complex processes; and Life Cycle Assessment is growing rapidly, especially in Europe where 130 LCAs were done in 1994.

In the United States, LCAs have been done since 1969 for the products listed in Table 1.

A model for an LCA (Figure 1) consists of inputs (raw materials and energy); life cycle stages (raw materials acquisition, manufacturing, use/reuse/maintenance, and recycle/waste management); and outputs (atmospheric emissions, waterborne wastes, solid wastes, coproducts, and other releases).

Many conclusions can be reached using data inputs to the model. For example, is it less energy/environmentally demanding to recycle or dispose; can a product be re-configured to lessen its energy/environmental impact; are there preferable pollution control steps to minimize environmental impact?

LCA is not yet a regulatory requirement in the United States, as in Europe; but leading corporations and business organizations have voluntarily adopted the concept as a business principle.

## VOCABULARY:

LCA, ecobalance, cradle-to-grave analysis, holistic, environmental profile analysis

## PROCEDURE:

### *Setting the Stage*

1. Discuss Life Cycle Assessment and what it means in terms of our environment.

### *Activity*

1. Ask the students their opinions as to why Europe has regulated LCA and the United States has not.
2. Using the LCA model provided, have the students construct their own LCA for common consumer products. For example, they might construct an LCA for an aluminum can or plastic soft drink bottle.
3. Using Figure 1, discuss any packaging changes that may have occurred in certain grocery store or fast-food products as a result of an LCA of the product.

## Grades:

9 - 12

## Subjects:

Biology, Chemistry,  
World History, Environmental Science

## Time Needed:

50-minute class period (allow one week for researching European LCAs)

## Materials:

materials gathered from research

4. Have the students make a list of companies in the U.S. that they think are LCA sensitive and state the reasons upon which they base their opinions. The students also could make a list of companies that they think are not LCA sensitive and explain why they feel these companies are not sensitive.

### **EXTENSION:**

1. Students could choose roles of people in these companies and their communities and could debate the issues of LCA in Alabama.

### **ORIGINAL DEVELOPMENT RESOURCES:**

Broad-Based Environmental Life Cycle Assessment. (1993, March). *Environmental Science and Technology*, 430.

Learning to Live with Life Cycle Assessment. (1994, May). *Environmental Science and Technology*. 236a.

[www.life-cycle.org](http://www.life-cycle.org)

[www.quantis-intl.com/life\\_cycle\\_assessment.php](http://www.quantis-intl.com/life_cycle_assessment.php)

<http://environment.nationalgeographic.com/environment/national-geographic-sustainability/magazine-life-cycle-assessment/>

**Table 1****Life Cycle Assessments in the United States**

<b>Client</b>	<b>Practitioner</b>	<b>Product</b>	<b>Year</b>
Coca-Cola	MRI	Beverage containers	1969
EPA	MRI	Beverage containers	1974
SPI	MRI	Plastics	1974
Unknown	MRI	Beer containers	1974
Goodyear	Franklin	Soft drink containers	1978
Procter & Gamble	Franklin packaging	Laundry detergent	1988
Procter & Gamble	Franklin	Surfactants	1989
Unknown	Franklin	Softdrink delivery systems	1989
Council for Solid Waste Solutions	Franklin	Foamed polystyrene and bleached paperboard	1990
American Paper Institute	Franklin	Cloth and disposable diapers	1990
Council for Solid Waste Solutions	Franklin	Grocery sacks	1990
Vinyl Institute Systems	Chem	Vinyl packaging	1991
National Association of Diaper Services	Lehrbergerr & Jones	Diapers	1991
Council of State Governments	Tellus	Packaging	1991
Procter & Gamble	Franklin	Hard surface cleaners	1992
Procter & Gamble	A. D. Little	Cloth & disposable diapers	1990

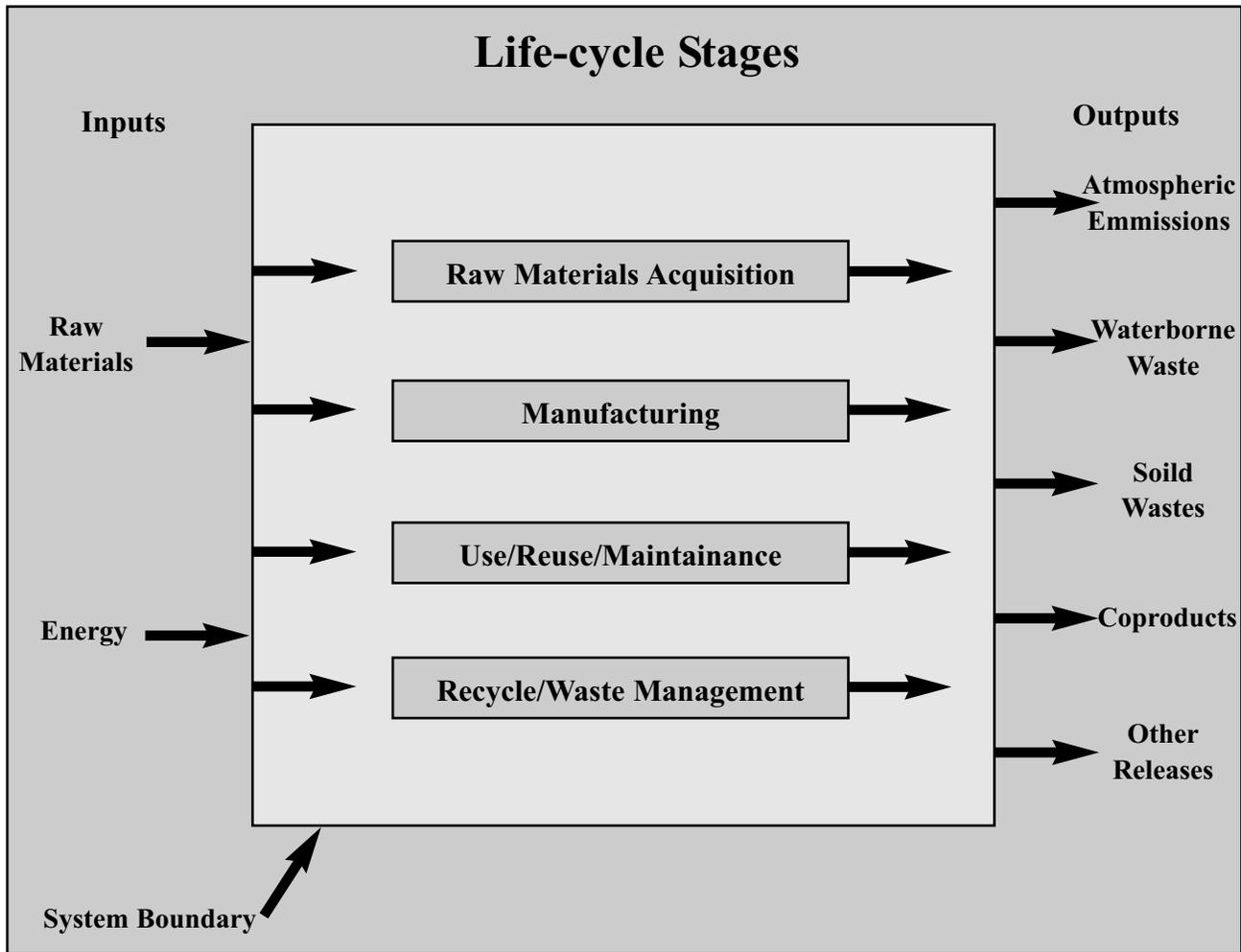


Figure 1. Model for a Life Cycle Assessment

## OBJECTIVES:

Students will be able to:

1. Investigate the role of trees in energy conservation.
2. Compare and contrast the inside temperatures of model houses painted black and white.

## BACKGROUND:

One important way to save energy is by landscaping with trees and other vegetation around the home. Landscaping provides an effective, natural way to prevent heat loss and heat gain in the home. When the home stays cool in the summer and warm in the winter, the air conditioner and heater are used less frequently. Consequently, energy is saved.

Deciduous (leaf losing) trees placed on the west and east sides of a house are the most effective at shading and cooling because they block the morning and afternoon sun, especially in the summer. Because they are bare in the winter, the trees allow the winter sun to warm the house.

If one lives in a large apartment building or an area that does not have space for trees, one still can receive the cooling and shading benefits of trees. Trees planted along streets and around schools, churches, and office buildings also help to conserve energy.

Another energy-saving measure that goes hand-in-hand with landscaping is light-colored surfacing. If a person has ever stepped barefoot on asphalt in the summertime, he/she probably ran as fast as possible to the light-colored sidewalk or, even better, to a shady spot on the grass.

The street is much hotter than surrounding areas because dark surfaces absorb solar radiation while light-colored surfaces reflect it. By lightening the colors of buildings, parking lots, and pavements, communities can reduce the amount of energy required for cooling by as much as 50 percent. A combination of trees and light-colored surfaces can make a significant difference in temperature.

## VOCABULARY:

deciduous, solar energy, absorption, reflection

## PROCEDURE:

1. Construct three model houses out of foam or cardboard. The structures can be as simple or as complex as the students wish, but the dimensions and features of each must be consistent (a good size is 9" wide x 6" deep x 10" tall). The roof of each house must be removable. Build each on a base slightly larger than the house. The entire outer surface of one house must be black, and the entire outer surface of the other two must be white.
2. On a clear day, remove the roof and place a thermometer in each house, making sure its position is consistent in all three houses. Secure the thermometers with tape and replace the roofs. Place the houses

## Grades:

9-12

## Subjects:

Physics, Environmental Science,  
Geometry, Architectural Arts

## Time Needed:

Four to five 40-minute class periods.

## Materials:

four 20x20 inch sheets of white or light-colored foam core or cardboard  
scalpel or artist's knife (such as an X-Acto knife)  
black paint  
paper or other "surfacing" material  
outdoor thermometers  
glue  
sturdy tape such as masking or duct tape

outside. Put the dark-surfaced house and one of the light-surfaced houses together in a spot that will get sun all day. Place the other light-surfaced house in an area shaded by trees or other vegetation. Leave the houses outside for several hours.

3. After several hours, touch the roof and exterior walls of each house. Is there a significant difference in temperature?
4. Remove the roofs and check the internal temperature. Record the temperatures and compare them.
5. Discuss these questions as a class, in groups, or in journal entries:
  - Is there a difference in temperature among the three houses or just between the light and dark ones?
  - What can be concluded from the outcome of the experiment?
  - How is the model similar to “the real thing?” How is it different?

### **EVALUATION:**

1. The students should keep records of their experiment and should use graphs or charts to explain the outcome of their experiments. The teacher should make sure that students have carefully answered any questions associated with the lesson.

### **EXTENSIONS:**

1. Students could study the seasonal angles of the sun and then locate trees around the built houses. The prior experiment could be performed again after trees have been placed around the houses. Data from the first “Cooler by Design” experiment could then be compared to data from the second experiment.
2. Have students investigate the school grounds to determine if, and where, trees could be planted to help save energy.

### **ORIGINAL DEVELOPMENT RESOURCE:**

Adapted from *Growing Greener Cities*. Used with permission.

<http://forestry.usu.edu/htm/city-and-town/tree-selection/planting-trees-for-energy-conservation-the-right-tree-in-the-right-place>

<http://www.arborday.org/globalwarming/summerShade.cfm>

## OBJECTIVES:

Students will be able to:

1. Define carrying capacity.
2. Explain how population size is related to quality of life.

## BACKGROUND:

Carrying capacity refers to the ability of a habitat to sustain a population. Technology is the ability of a population to adapt to new circumstances by inventing new tools and ways of managing resources.

## VOCABULARY:

technology, carrying capacity, population

## PROCEDURE:

1. Define carrying capacity (See “Background”). Emphasize the fact that carrying capacity is in a constant state of change as populations, availability of resources, and technological skills are always changing.
2. Define technology as a way that people adapt to new conditions and solve problems.
3. Read this to the students:

On July 7, 1986, the Associated Press reported that sometime during that day, the five billionth person would be added to the Earth. The following letter was written to the editor of the newspaper in response:

To the editor: In *The Oregonian* (July 7), Associated Press reported the imminent birth of this planet’s 5 billionth person, casting it as ‘a sobering symbol’ with ‘staggering consequences’ of overpopulation. Yet, if all 5 billion people were placed on the land area of Canada (+) 3,560,238 square miles, every man, woman and child would have 19,851 square feet of space, with the rest of the continent and the rest of the planet empty.

All the space and resources we need are here. It’s for us to learn how to use them.

4. Ask the students these questions:
  - Do you agree or disagree with the letter? Why?
  - Do you think that this individual would agree with the theory of carrying capacity as applied to human populations?
  - What enables the human population to exceed limiting factors such as food scarcity?
5. Tell students that the modern human population of the world today is more than six billion and projected to be greater than ten billion by 2025. What might this mean for resources, technology, and society?
6. Have the students research and find:
  - The current population of Alabama.
  - The current population of their city.
  - The square feet of space each Alabamian has.

## EVALUATION:

1. Have students write an essay on technology, population, and resources.

### Grades:

9-12

### Subjects:

Social Science, Biology, Civics, Economics, Science

### Time Needed:

Two or three class periods of 1 hour each

### Materials:

research materials

**EXTENSION:**

1. Students could write letters to the local or student newspaper about this issue.

**ORIGINAL DEVELOPMENT RESOURCES:**

Adapted from *American Forests Global Relief*. Used with permission.

[www.worldgame.org](http://www.worldgame.org) (current world population counter)

## OBJECTIVE:

Students will be able to:

1. Synthesize specific aspects of environmental issues by acting out the roles of the people impacted by these issues.

## BACKGROUND:

Students frequently deal with environmental issues, but it is only from a superficial viewpoint. Rarely do they have the opportunity to view an issue from the perspective of real involvement. Role playing gives students the chance to put their feelings into a specific situation. When this happens, their views about an issue may change. They may realize that many issues have no clear-cut, “easy answers.” This case study can be about any real issue taken from the newspaper or from various news periodicals, researched by the students, and debated in class.

## VOCABULARY:

This can vary depending upon the issue(s) to be debated.

## PROCEDURE:

1. Have the students select and research an environmental issue.  
*Note:* The student is not allowed to argue from the way he/she truly feels but must assume the role of one of the people involved and must be able to argue in favor of that position.
2. Have the students, either individually or in small groups, assume the role of various players on all sides of the issue. Typical roles will depend on the issue to be debated. This example assumes the issue of water pollution:
  - Homeowner with polluted water or other environmental problem.
  - Homeowner with clean water but whose water bill will double to help cover the costs of a new water system.
  - Company president whose job is to keep the company financially sound.
  - Stockholder of the company.
  - Federal EPA or environmental official.
  - Alabama Department of Environmental Management.
  - Mayor or city council person.
  - Consumer who buys products made by the company.
  - Lawyer representing a homeowner or another player in the scenario.
  - Environmental scientist.
  - (The rest of the class can be the “voting public.”)
3. Students should read the periodical(s) containing the issues to be debated. As they read the story, have them focus on the questions that develop in the story. Give them time to formulate answers to those questions in preparation for classroom discussion. If possible, have them get in a circle and start discussing the questions based on the role each has assumed.
4. Once the students are familiar with this approach, the teacher can let the students go with their arguments representing the views of the roles they have assumed. Sometimes the teacher may need to act as a mediator or may need to clarify some of the points a group has made.

## Grades:

9-12

## Subjects:

Environmental Science, Social Studies

## Time Needed:

About a week of in-class time or can be done as an outside assignment. Time is needed for the students to gather the materials on the issue and to research the people impacted by the issue. The actual town/world council will take about two hours for presentation or two individual class periods.

## Materials:

list of roles of various people or companies impacted by the issue to be debated  
news periodicals on the issue  
place cards for role identification

5. Typically, students cannot reach closure on the day of the debate. Assign a period of time, possibly three days, for the groups to debate on their own; and have them report their decisions to the class.

### **EVALUATION:**

1. Teacher may evaluate research and clarity in voicing opinions based on fact.

### **EXTENSIONS:**

1. A typical issue might be the water wars between Alabama and Georgia. Invite the people involved in the issues to speak to the class during the post-debate period.
2. Do “Are You Willing to Trade (Off)?” extension activity. (See next activity.)

### **ORIGINAL DEVELOPMENT RESOURCES:**

Alabama Department of Economic and Community Affairs - Office of Water Resources; 334-242-5499, 1-877-252-9283, [water@adeca.alabama.gov](mailto:water@adeca.alabama.gov), [www.adeca.state.al.us](http://www.adeca.state.al.us)

# Extension Activity:

## Are You Willing To Trade (Off)?

### OBJECTIVES:

Students will be able to:

1. Define “trade offs” and give at least two specific examples.
2. Compare the impacts, both positive and negative, for at least one local industry.
3. Identify appropriate resource material.
4. Develop and analyze survey results (extension).

### BACKGROUND:

This activity will help students focus on both sides of an issue. Students are often passionate in their beliefs without thinking through all of the consequences of what they are assuming. Students need to understand that most solutions involve accepting the best compromise. To gain benefits, we usually also give up other benefits.

The teacher should determine the local industries to select so that materials and information are readily available. Depending on the age and ability of the students, the teacher may wish to have the information in the classroom for students to use.

### VOCABULARY:

trade offs

### PROCEDURE:

#### *Setting the Stage*

1. Write the words “TRADE OFFS” on the board and ask the students what thoughts come to their minds when they read this. Solicit as many responses as possible. Guide their thoughts to cover such things as “give and take,” and “compromise.”
2. Ask for examples of trade offs they make at home, at school, and in the use of their time. continue this until they have a good working feeling for the idea of trade offs.

#### *Activity*

1. Divide the class into groups and assign each group a local industry. (Use specific local industries or businesses.)
2. Give each group a copy of the Industry Investigation survey form, and assist students in filling out the top portion.
3. Explain the instructions (see form). Answer questions about the assignment.

### EVALUATION:

Student projects will be graded on the following:

1. Did they follow the assignment and complete the work on time?
2. Were facts gained from accurate sources, and were they properly cited?
3. Were presentations well planned and ready on time? Did they show evidence of understanding and research?
4. Did all group members participate equally?

### Grades:

9-12

### Subjects:

Environmental Science

### Time Needed:

Research time both in and out of class;  
30 minutes to present the activity;  
total presentation time based on the  
number of groups presenting

### Materials:

handouts/one per group  
example to post on bulletin board

## **EXTENSIONS:**

1. Arrange for a field trip for the class or groups of students to tour one of the industries.
2. Bring in a speaker from one of the industries to talk with the class about the environmental changes they are making within the industry.
3. Let the students develop and take a survey of the general public to assess their impression of the industry in relation to environmental issues, and compare this to the class reaction before and after this activity. Graph and analyze the results. (Caution: surveys of human subjects must be structured carefully and with adult supervision. The methodology and questions to be asked in the surveys should be chosen carefully and should be approved by the teacher.)
4. Rather than selecting industries, choose an environmental issue to investigate.

## **ORIGINAL DEVELOPMENT RESOURCES:**

Local chamber of commerce, governments, and media environmental reporters.

Environmental and industry groups and professional organizations. Refer to links on Bama Environmental News website at [www.bamanews.com](http://www.bamanews.com).



# Notes

# A Futurist Writer's View on the Environment

## OBJECTIVES:

Students will be able to:

1. Interpret written social theories and support or dispute them.
2. Discuss the meaning and implications of social theories.

## BACKGROUND:

Alvin Toffler, one of the world's best-known social thinkers as well as a contributor to management literature and a member of the American Academy of Science, wrote a trilogy of international best-selling books about the world's movement into the 21st century. The first, *Future Shock*, originally published in 1970, looked at the process of change and how change affects people and organizations. The second, *The Third Wave* (1980), focused on the directions of change and where today's changes are taking us. The third in the trilogy, *Power Shift* (1990), dealt with the continued changes still to come, who will shape them, and how they will accomplish that.

In another book following the trilogy, *War and Anti-War* (1995), he discussed the future of global military and political conflicts, with the term "national security" broadened to include ecological components.

## VOCABULARY:

thermopollution, social overhead, life cycle assessment, exploitation of nature, diversity, defoliant, vector, laser

## PROCEDURE:

Advance preparation: Review the attached excerpts of Toffler's books and assign them to students for an essay, debate, point-counterpoint discussion, or analysis of events that corroborates or does not corroborate Toffler's theories.

1. Explain the background of Toffler's books, the reason they were written, the times in which they were written, and the environmental status of the world at each of those times.
2. Assign the environmental excerpts to students as a theme to support, expound upon, or dispute Toffler's theories.
3. Use the excerpts as the basis for debate or reading comprehension exercises, or discuss their value as a guide into the 21st century.
4. Assign an out-of-class paper, oral presentation, or class debate for students to further examine Toffler's theories through real-world examples.
5. Analyze the excerpts relative to their time of publication; hypothesize about the environment's status in each era represented by the books, about public attitudes about the environment in each era, and about present environmental values, attitudes, and directions.

## ORIGINAL DEVELOPMENT RESOURCES:

Toffler, A. (1970). *Future Shock*.

Toffler, A. (1980). *Third Wave*.

### Grades:

9-12

### Subjects:

Social Science, Literature, Civics, Environmental Science

### Time Needed:

One or two class periods of 50-60 minutes each

### Materials:

Toffler excerpts from appropriate books

Toffler A. (1990). *Power Shift*.

Toffler, A, & Toffler, H. (1995). *War and Anti-War*.

Toffler excerpts (see attached)

[www.maslowtoffler.com](http://www.maslowtoffler.com)

# Toffler Excerpts

**Toffler, *Future Shock*, 1970, pp. 429-430.**

## Environmental Stewardship

Our technological powers increase but the side effects and potential hazards also escalate. We risk thermopollution of the oceans themselves, overheating them, destroying immeasurable quantities of marine life, perhaps even melting the polar icecaps. On land we concentrate such large masses of population in such small urban-technological islands, that we threaten to use up the air's oxygen faster than it can be replaced, conjuring up the possibility of new Saharas where the cities are now. Through such disruptions of the natural ecology, we may literally, in the words of biologist Barry Commoner, be "destroying this planet as a suitable place for human habitation."

**Toffler, *Future Shock*, 1970, p. 442.**

## Who Pays Environmental Costs?

The costs of air pollution are similarly borne by taxpayer and community even though, as is often the case, the sources of pollution are traceable to individual companies, industries, or government installations. Perhaps it is sensible for de-pollution costs to be borne by the public government as a form of social overhead, rather than by specific industries. There are many ways to allocate the cost. But whichever way we choose, it is absolutely vital that the lines of responsibility are made clear. Too often no agency, group or institution has clear responsibility.

**Toffler, *Power Shift*, 1990, p. 79.**

## The Concept of Life Cycle Assessment

We are, in fact, discovering that "production" neither begins nor ends in the factory. Thus, the latest models of economic production extend the process both upstream and downstream, forward into aftercare or "support" for the product even after it is sold, as in auto-repair warranties or the support expected from the retailer when a person buys a computer. Before long, the conception of production will reach even beyond that to ecologically safe disposal of the product after use. Companies will have to provide for post-use cleanup, forcing them to alter design specs, cost calculations, production methods, and much else besides. In so doing they will be performing more service, relative to manufacture, and they will be adding value. "Production" will be seen to include all these functions.

**Toffler, *Power Shift*, 1990, pp. 369, 373, 378.**

## The Green Movement

[The Green Movement has two sides.] on one side: those who favor technological economic advances within stringent environmental constraints. Unwilling to give up on imagination and intelligence, they believe in the power of the human mind, and therefore in our ability to design technologies that will use smaller amounts of resources, emit less pollution, and recycle all wastes into valuable resources....Oriented toward tomorrow, these are the mainstream environmentalists.

Battling them for ideological control...are self-described "fundamentalists," who wish to plunge society into pre-technological medievalism and asceticism. What the eco-medievalists normally do not tell us is the political price. They seldom point out that democracy was conspicuously absent from those bucolic villages they hold up for emulation, villages ruled by the cruelest patriarchy, religious mind-control, feudal ignorance, and force. Governments controlled or heavily influenced by extremists who put their particular brand of religion, ecology, or nationalism ahead of democratic values do not stay democratic for long.

## **Toffler Excerpts (con't)**

**Toffler, *The Third Wave*, 1980, pp. 8, 16, 301, 342, 383, 416, 421.**

### Patterns of Change

The First Wave of human progress was the development by man of agriculture, cultivated land and a new way of life, lasting until about 1750. With the coming of the Second Wave (1750-1955), civilization once found capitalist industrialists gouging resources on a massive scale, pumping voluminous poisons into the air, deforesting whole regions in pursuit of property, without much thought about side effects or long-term consequences. The idea that nature was there to be exploited provided a convenient rationalization for shortsightedness and selfishness.

Shortly after 1955 white collar workers outnumbered blue collar workers for the first time, the computer, commercial jet travel, the birth control pill and many other high-impact innovations appeared. National borders that can no longer contain economic flows are now even less defensible against environmental forces. The Third Wave represents a shift to higher diversity in society, a faster pace at which change occurs, and requires a change in leadership direction to one of the depending upon, and listening to others.

Second Wave thinking opposes change, pooh-poohs environmental concerns and opposes the move to a fairer world economic order. Third Wave thinkers favor more individualization in the schools, place higher priority on environmental problems, and have a lack of confidence in the present political framework.

The responsibility for change, therefore lies with us. We must begin with ourselves, teaching ourselves not to close our minds permanently to the novel, the surprising, the seemingly radical. This means fighting off the idea-assassins who rush forward to kill any new suggestion on grounds of its impracticability, no matter how absurd, oppressive, or unresolvable it may be. If we begin now, we and our children can take part in the exciting reconstitution of not merely our absolute political structures, but of civilization itself.

**Toffler, *War and Anti-War*, 1995, pp. 286, 183, 143.**

### Ecological Militarism

Few words are more loosely thrown about today than the term "global." Ecology is said to be a "global" problem. The very notion of "national security" is being broadcast to include not simply military but economic, diplomatic, and even ecological components. [One proponent] argues that to head off trouble before it explodes, the United States should use its intelligence and its military forces to help the world deal with problems like hunger, disaster and pollution that can throw disparate populations into violent conflict.

And then there is ecological weaponry [as] when Saddam Hussein torched the Kuwaiti oil fields...the Romans salted the fields of Carthage...during World War II the Russians pursued their "scorched Earth" policy to deny food to the Nazi invaders...and what the United States did with the use of defoliants in Vietnam.

[Modern day] possibilities of sophisticated ecological weaponry...[include] triggering earthquakes or volcanic eruptions at a distance by generating certain electromagnetic waves; deflecting wind currents; sending in a vector of genetically-altered insects to devastate a selected crop; using lasers to cut a custom-tailored hole in the ozone over an adversary's land; and even modifying weather.

## OBJECTIVES:

Students will be able to:

1. Compute the amount of water used to flush a toilet.
2. Describe ways to reduce the amount of water used to flush a toilet.
3. Define and compute mean and range.

## BACKGROUND:

Did you know there is the same amount of water on Earth today as there was three billion years ago? This amounts to approximately 326 million cubic miles of water covering 71 percent of the Earth. Nearly one-half of the world's population lacks access to clean water for sanitation, drinking, and other human needs. One could survive about a month without food but only five to seven days without water.

In some parts of the world, saving water is a necessity; but in Alabama it is a responsibility. It saves money, helps protect the environment, helps prevent water pollution, and helps preserve our water resources. Conservation by homeowners can be achieved by simply reducing the amount of water used to flush a toilet. Each time the toilet is flushed, it uses five to seven gallons of water. To reduce this by 15 to 40 percent, a displacement device can be used in the tank.

## VOCABULARY:

displacement, mean, range

## PROCEDURE:

### *Setting the Stage*

1. Using background information and data from current publications, the teacher can relate facts about the amount of water available on the Earth and the quality of this water.
2. Have each student complete a "How Do You Measure Up?" quiz (attached).
3. After totaling the score, students can determine how they "measure up" in taking care of the Earth's water supply by referring to the scale at the end of the quiz.
4. Have students share their results with the class, and have them discuss how they can become better caretakers of the Earth's water supplies.

### *Activity*

1. Give each student a flush frequency chart (attached), and explain that each flush should be recorded on the chart. This should be done for a period of four days covering Thursday, Friday, Saturday, and Sunday.
2. Place a few pieces of gravel in the bottom of the plastic bottle. Fill the bottle with water, and place it in the tank of the toilet. Be careful that the bottle does not interfere with the proper flushing of a toilet. This becomes a displacement device resulting in less water being used for each flush.
3. Using data from the flush frequency chart, calculate the following amounts of water saved in:
  - One day.
  - One week.
  - One year.

## Grades:

9-12

## Subjects:

Environmental Science, Math

## Time Needed:

Two class periods

## Materials:

"How Do You Measure Up?" quiz  
small dishwashing or laundry plastic  
bottle  
several pieces of gravel  
checklist to record the number of  
flushes in a two-day period

**EVALUATION:**

1. A flush frequency chart must be completed.

**EXTENSIONS:**

1. Use this information to determine the amount of money saved over the period of one year. One gallon of water costs \$.004.
2. Have the students devise another means of conserving water.
3. Students can collect data for one week or longer.
4. Have students determine the sources of water in their communities or homes.

**ORIGINAL DEVELOPMENT RESOURCES:**

Buchanan, P.; Carter, P.; McSwean, S.; & Wilson, C. (1992). *Discover Alabama III* Activities Booklet, Alabama Commission on Higher Education.

*Water Quality and Pollution Control Handbook* Circular, ANR-790, Alabama Cooperative Extension System. [www.aces.edu](http://www.aces.edu)

Water in Alabama, (current year), Geological Survey of Alabama.

“Alabama Water Resources” poster, Legacy, Inc. P.O. Box 3813, Montgomery, AL 36109, [www.legacyenvd.org](http://www.legacyenvd.org), 1-800-240-5115.

Alabama Cooperative Extension System website, [www.aces.edu](http://www.aces.edu).

## Don't Flush It Away

### How Do You Measure Up? A Water Awareness Test

Every day we do things that positively or negatively affect the amount of water we use and the condition or "quality" of the water we dispose. Here's an opportunity for you to consider what your contribution is to the problem and to the solution. Take a few minutes to complete this checklist. Add up the numbers you circled as answers in each column to find your total. Then use the "How Did You Score?" section at the end to determine what your score means.

#### **Part 1: Do you**

	<b><u>Never</u></b>	<b><u>Sometimes</u></b>	<b><u>Often</u></b>
1. Leave the tap water running as you brush your teeth or shave?	1	2	3
2. Throw used containers of paint, solvents, or harsh cleansers into the trash?	1	2	3
3. Empty leftover paint solvents or cleansers into house drains?	1	2	3
4. Run the washing machine with small loads?	1	2	3
5. Use lots of fertilizer and lawn feeder to help the lawn recover from winter?	1	2	3
6. Leave the shower running to heat up the bathroom?	1	2	3
7. Wait to repair a dripping faucet until it turns into a steady leak?	1	2	3
8. Wash the car every weekend in the summer?	1	2	3
9. Change the oil in the street or use storm drains to dispose of used oil?	1	2	3
10. Use the toilet to dispose of ordinary waste around the house?	1	2	3
11. Attend public hearings on water issues?	3	2	1
12. Consider the impact of land-use and zoning decisions on your water resources?	3	2	1
13. Volunteer to help clean up a body of water or promote water quality awareness in your community through a program such as "Adopt a Stream"?	3	2	1

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#### **Part 2: Do You .....**

	<b><u>Yes</u></b>	<b><u>No</u></b>
Know where your tap water comes from?	1	3
Know where your waste water goes?	1	3
Know who operates your water utilities?	1	3
Know the name and location of your watershed?	1	3
Know how much it costs to purify your drinking water and to clean your wastewater?	1	3
Operate the dishwasher only for full loads?	1	3
Fill the tub to a high level when you take a bath?	3	1

Add Part I \_\_\_\_\_ +Part II \_\_\_\_\_

Total score = \_\_\_\_\_

# **Don't Flush It Away**

## **How Did You Score?**

### **If your total score was:**

#### **24 or less**

You are to be complimented on your knowledge of water resource issues and your commitment to practicing sound conservation and pollution prevention measures.

#### **25-44**

You are generally aware of the need to conserve water and to protect surface and groundwater from pollution, but you need to be more consistent in your habits. Remember, even small leaks result in huge losses, and small quantities of pollutants can contaminate large bodies of water.

#### **45-60**

Unfortunately, like too many others, you may be contributing to severe water supply and pollution control problems in your community. You need to think about the many ways you can modify your habits to become part of the solution.

## Flush Frequency Chart

Anyone who flushes the toilet should place a check mark on the line next to the day of the week under the proper column each time a flush is made. Average number of gallons per flush = five. Multiply number of flushes by 5 to get gallon used per day.

Day One (Thursday) \_\_\_\_\_ x 5 =      Day One Total \_\_\_\_\_ gallons

Day Two (Friday) \_\_\_\_\_ x 5 =      Day Two Total \_\_\_\_\_ gallons

Day Three (Saturday) \_\_\_\_\_ x 5 =      Day Three Total \_\_\_\_\_ gallons

Day Four (Sunday) \_\_\_\_\_ x 5 =      Day Four Total \_\_\_\_\_ gallons

Lowest number of flushes per day \_\_\_\_\_

Highest number of flushes per day \_\_\_\_\_

Range \_\_\_\_\_

Daily Average (weekday) \_\_\_\_\_

Daily Average (weekend) \_\_\_\_\_

Daily Average (total) \_\_\_\_\_

With the use of a simple displacement device, a savings of 1.5 gallons of water is made with each flush. Complete the chart below to determine how much water could be saved in one year at your home.

One day \_\_\_\_\_ = \_\_\_\_\_  
 (use the daily average number  
 of flushes x 1.5)

One week \_\_\_\_\_ = \_\_\_\_\_

One month (30 days) \_\_\_\_\_ = \_\_\_\_\_

One year \_\_\_\_\_ = \_\_\_\_\_

# Notes

## OBJECTIVES:

Students will be able to:

1. Set up and conduct a controlled experiment by exploring the heating potential of solar energy.
2. Measure and record the temperature of water each minute for a 20-minute period.
3. Graph the results and describe their results in paragraph form.

## BACKGROUND:

In many homes, the water heater is second only to the heating system in total energy consumption. To heat their water and homes, most people use fossil fuels: coal, oil, or natural gas.

In Alabama, electricity is typically produced by power plants that burn coal, but hydroelectric dams and nuclear power plants also are used to produce electricity.

Advances in solar technology enable people to harness the sun's power and use it successfully to heat their water and to cool and heat their homes. Today, a family has the option of using a solar water heater to reduce monthly utility bills while helping to conserve rapidly diminishing fossil fuel reserves. More than 1.7 million Americans use some form of solar energy in their homes. In 2001, and more than 350 megawatts of commercial capacity are operating today, according to the Solar Energy Industry Association.

There are more than 1 million American using solar water heaters; more than 1/2 million using solar to heat their swimming pools; more than 1/4 million homes using solar electric (PV) technology.

A basic understanding of the uses for, and potential of, solar energy continues to become increasingly relevant because of "global warming" possibly caused by the dependence of industrialized nations on fossil fuels.

Solar water heaters need to be located in direct sunlight. To increase the absorption of heat, the water storage container should have a large surface area, a transparent or translucent glazing, and a dark bottom surface (a flat black paint is often used). The container also should be tightly sealed so that it benefits from the "greenhouse" effect.

The greenhouse effect is best demonstrated by a car left in the sunlight with its windows rolled up. The inside of the car soon becomes uncomfortably hot. This happens because sunlight consists mostly of visible light, which passes easily through clear glass or plastic windows, and energy such as infrared, which is blocked by a clear window. Inside the car, the visible light is absorbed by the dashboard, seats, and flooring, warming them and, in return, re-radiating at longer wavelengths, i.e., infrared. Because the infrared radiation cannot easily escape through the window glass, heat keeps accumulating inside the car. That's the reason we roll down car windows to cool off a car quickly to let in fresh air, which replaces the previously trapped hot air.

## Grades:

9 - 12

## Subjects:

Physical Science, Biology, Chemistry, Earth Science

## Time Needed:

Two class periods of approximately 60 minutes each

## Materials:

paper cups holding 150 milliliters of water at room temperature  
thermometers  
aluminum pie pans  
pieces of cardboard on which to set the pans  
clear plastic bags  
colored plastic bags  
pie pans painted black  
pie pans of smaller diameter  
plastic containers  
activity sheets for recording results  
watch or clock  
graph paper  
flat black spray paint

## **VOCABULARY:**

greenhouse effect, controlled experiment, global climate change, fossil fuel, visible radiation, infrared radiation

## **PROCEDURE:**

### **Day One:**

1. Begin the activity by explaining to students that they are going to experiment using the sun to heat water. Using aluminum pie pans, they are going to test how fast the sun heats the water. This experiment will work best on a sunny day; but even on a cloudy day, they'll get interesting results.
2. Demonstrate setting a pan without water on a level surface on top of a piece of cardboard, which helps insulate the pan. Caution students to make sure all pans have the same amount of water by adding the water after the pan is in its experimental position in the sunlight. Moving the pan around may spill the water. Show students the paper cup that holds 150 milliliters and demonstrate using the cup to measure and add water to the pan. Then demonstrate how they should carefully immerse the thermometer in the water.
3. Divide the class into groups and give each group the supplies it will need. Have students set up their equipment on level surfaces. Before students measure out and pour a full paper cup of water into their pie pans, have them feel with their fingers how cold or warm the water is. Ask: How can we determine what is the change in water temperature? Hand out the activity sheets and explain how students should use the sheets to record their data and calculate the change in water temperature.

### **Day Two:**

1. As a class or in groups, decide which variables students will test. Ask: How should we set up the supplies so the test is fair and can be compared with our results in the first heaters we tested? Make sure that the class understands the concept of a fair test (controlled experiment) and that they need to use the same amount of water they tested on Day One (150 milliliters).
2. Give each group several activity sheets, and tell them to use those sheets to record and graph their results. Have the student groups set up and test their experiments. Have them also set up a control water heater, the same pie pan set up in Day One, so they can compare their results against it. Graph all results on one large graph.

## **EVALUATION:**

1. Accuracy in carrying out laboratory procedures may be checked; completed activity sheets may be graded.

## **EXTENSIONS:**

1. Locate willing teachers in other parts of Alabama/United States/world, and ask them to let their students conduct similar experiments on the same day. Let the classes share results electronically by fax, e-mail, or the Internet. They may note variations and hypothesize about reasons. Make sure that all experiments use the same temperature scales (Fahrenheit or Centigrade).
2. Allow individual students to do library research and report on areas in which solar energy is abundant and on areas in which it is not. (This could be an optional exercise available for extra credit.)

## **ORIGINAL DEVELOPMENT RESOURCES:**

*Explore*, a booklet published by the National Science Foundation encouraging teachers to recognize National Science and Technology Week, 1995.

America's Solar Energy Potential [www.americanenergyindependence.com](http://www.americanenergyindependence.com)

Solar Energy Potential [www.energy.gov/maps/solar-energy-potential](http://www.energy.gov/maps/solar-energy-potential)

## Data Collection

**Directions:** List the equipment in each of the set-ups. Record the temperature each minute for 20 minutes.

### Minutes

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	
<b>1.</b>																					
<b>2.</b>																					
<b>3.</b>																					

# Notes

## OBJECTIVES:

Students will be able to:

1. Determine how the ozone is formed and destroyed.
2. Determine the importance of the ozone layer and the environmental problems if there is too much or too little ozone.
3. Calculate data to determine if a hole is forming in the ozone layer.

## BACKGROUND:

Ozone is composed of three oxygen atoms as compared to diatomic oxygen molecules, which are composed of two oxygen atoms. About 90 percent of the total atmospheric ozone is located in a layer between approximately 15 and 50 kilometers above the Earth’s surface (the ozone layer) in the atmospheric region known as the stratosphere. (See Figure 1.) This upper-level ozone layer is different from the ground-level ozone that causes pollution and respiratory problems.

Upper-level ozone is quite rare. The stratosphere contains from 0.1 to 10 parts per million of ozone with much lower amounts closer to the ground. (See Table 1.) In contrast, the atmosphere contains more than 20 percent of diatomic oxygen, hundreds to thousands of times as much as the ozone. The ozone forms in the stratosphere by the sun’s rays hitting oxygen. The ozone is easily destroyed by the sun’s rays breaking down (photo-dissociation) various chemicals, including human-made chlorofluorocarbons (CFCs) such as Freon (used in air conditioners and Styrofoam) and propellants (used in aerosol cans). (See Figures 2, 3, and 4.) In addition, near the ground, the sun reacts with auto exhaust to make ozone a part of photochemical smog. In the classroom, ozone can be formed by a flint sparker.

Ozone is very important to human health. The upper-level ozone layer stops much of the ultraviolet radiation from the sun from reaching the Earth’s surface. These rays can cause skin cancer, mutations, and reduced crop yields. They also can harm plankton. Therefore, a decrease in the amount of stratospheric ozone could lead to human health problems. Conversely, too much ozone near the ground can lead to smog, such as is seen on summer days in many large cities, and can irritate the eyes and lead to respiratory problems. Concentrations of ozone near the ground are much lower than in the ozone layer, even in smoggy cities. While the concentration of ozone in the ozone layer is important to human health, an increase in concentration near the ground or a decrease in concentration in the ozone layer should be evaluated for possible environmental problems. It has been scientifically determined that a “hole” in the ozone layer is forming and growing over the polar regions of the Earth due to the release of CFCs and other gases (see Figure 5).

## VOCABULARY:

ozone, stratosphere, photo dissociation, chlorofluorocarbons (CFCs), Freon, propellant, aerosol can, smog, ultraviolet radiation

## PROCEDURE:

1. Students should make a bar graph of ozone concentrations versus altitude above Antarctica for 1987. (Use the data table in Table 2.)
2. Repeat Step 1 for 1993.

### Grades:

9-12

### Subjects:

Atmospheric Science, Environmental Science, Biology, Chemistry, Earth Science

### Time Needed:

40 minutes

### Materials:

graph paper

3. Students should identify the ozone layer on their bar graphs.
4. Calculate whether there has been an increase or decrease in ozone concentration in the ozone layer. Calculate the total change for the interval 1987-1993 and the percent change per year.
5. Discuss the environmental implications if this trend continues.
6. Compare data included in this activity with newer data from NOAA, located at [www.ozonelayer.noaa.gov](http://www.ozonelayer.noaa.gov).

### **EXTENSIONS:**

1. Students can compare maps of the ozone layer from the 1970s, 1980s, and 1990s. Older students can calculate rates of change. Maps can be obtained from sources listed in the resources section.
2. Students can compare historical photos of major Alabama cities to see if smog has gotten worse.
3. Students can contact the U.S. Environmental Protection Agency and/or the Jefferson County Department of Public Health to obtain information on ozone and smog levels in Alabama over the last 25 years.

### **ORIGINAL DEVELOPMENT RESOURCES:**

The U.S. Environmental Protection Agency. [www.epa.gov](http://www.epa.gov)

The Alabama Department of Environmental Management. [www.adem.state.al.us](http://www.adem.state.al.us)

The Jefferson County Department of Public Health [www.jcdh.org](http://www.jcdh.org)

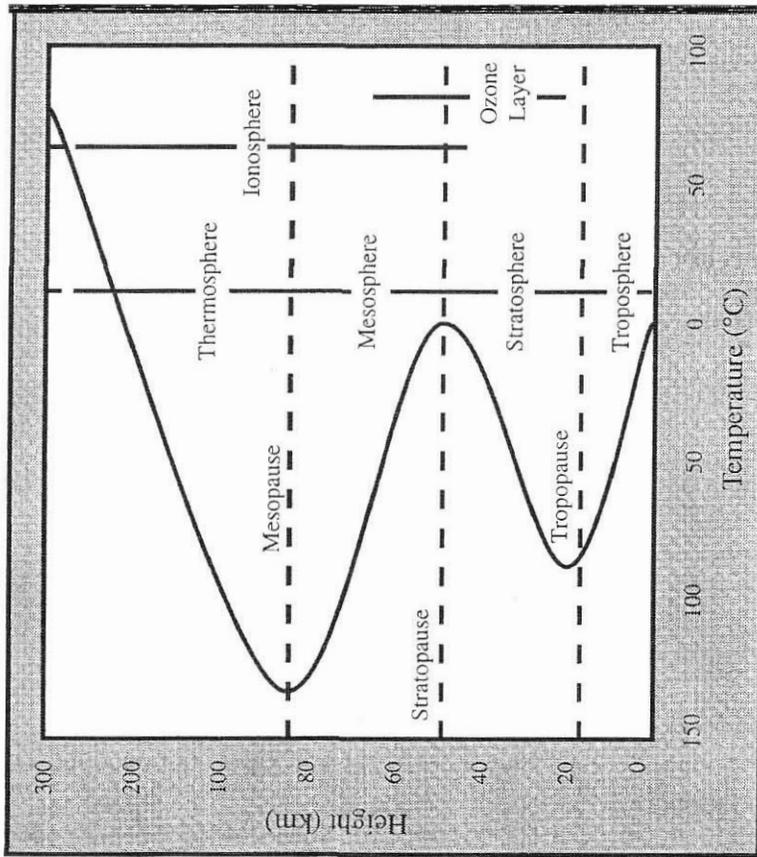
Alabama Partners for Clean Air: [www.alabamacleanair.org](http://www.alabamacleanair.org)

NOAA: Stratospheric Ozone monitoring and research website: [www.ozonelayer.noaa.gov](http://www.ozonelayer.noaa.gov)

**Table 1. Major and Selected Trace Gases in the Atmosphere**

Gases	Concentration
Nitrogen (N <sub>2</sub> )	78.08 percent by volume
Oxygen (O <sub>2</sub> )	20.95 percent by volume
Argon (Ar)	00.93 percent by volume
Water Vapor (H <sub>2</sub> O)	0 to 1 or 2 percent by volume
Carbon Dioxide (CO <sub>2</sub> )	350 ppmv
Ozone (O <sub>3</sub> )	0.02 to 0.1 ppmv
in troposphere	0.1 to 10 ppmv
in stratosphere	1.7 ppmv
Methane (CH <sub>4</sub> )	0.31 ppmv
Nitrous Oxide (N <sub>2</sub> O)	0.5 ppbv
CFC-12 (CF <sub>2</sub> Cl <sub>2</sub> )	0.3 ppbv
CFC-11 (CFCl <sub>3</sub> )	2.0 pptv
Halon-1301 (CBrF <sub>3</sub> )	1.7 pptv
Halon-1211 (CBrClF <sub>2</sub> )	0.015 pptv
Hydroxyl (OH)	0.02 pptv to 0.3 ppbv
in troposphere	
in stratosphere	
Nitric Oxide (NO)	0 to 1 ppbv
in troposphere	
in stratosphere	Up to 0.02 ppmv

*Note:* The concentrations of atmospheric gases are given in either percentage by volume (which is the same as parts per hundred by volume), parts per million by volume (ppmv), parts per billion by volume (ppbv), or parts per trillion by volume (pptv).



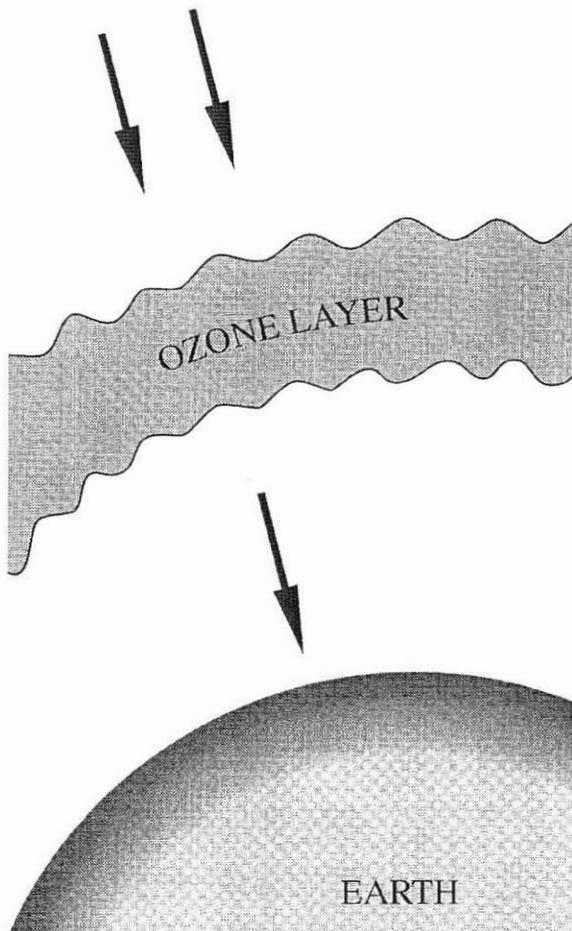
**Figure 1** The structure of the Earth's atmosphere illustrating the various regions. Each region is defined by its temperature gradient. (*Earth Systems Sciences Committee, NASA, 1988*)

**Table 2**

AVERAGE OZONE	CONTENT	
	1987	1993
<i>Altitude (km):</i>		
0-5	27	26
5-10	19	20
10-15	60	54
15-20	152	136
20-25	64	47
25-30	38	33
30-35	31	29
35-40	26	26

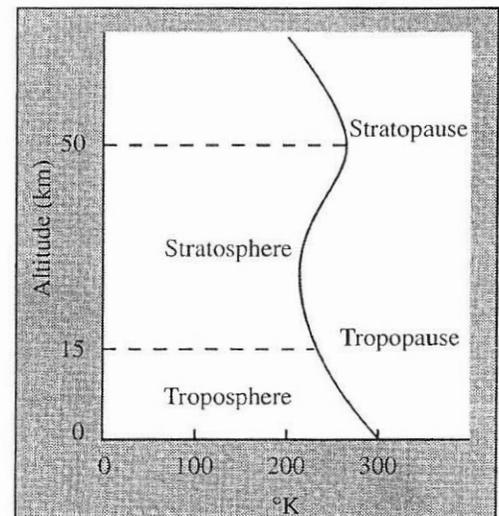
**Figure 3** Schematic diagram for absorption of solar radiation by ozone with the creation of the stratosphere (temperature increase with increasing altitude).

SOLAR U.V. CREATES OZONE,  $O_3$

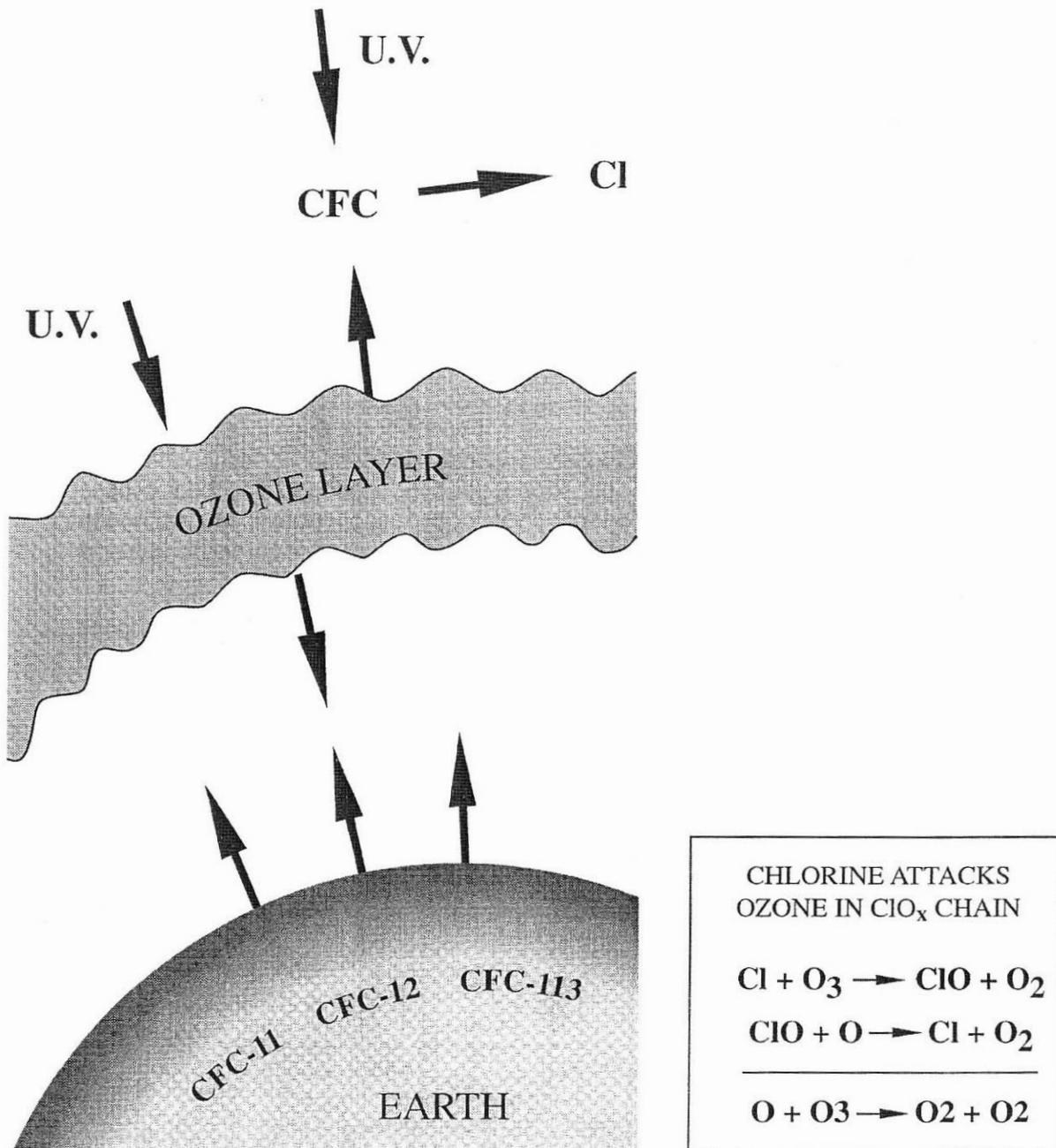


OZONE ABSORBS U.V.

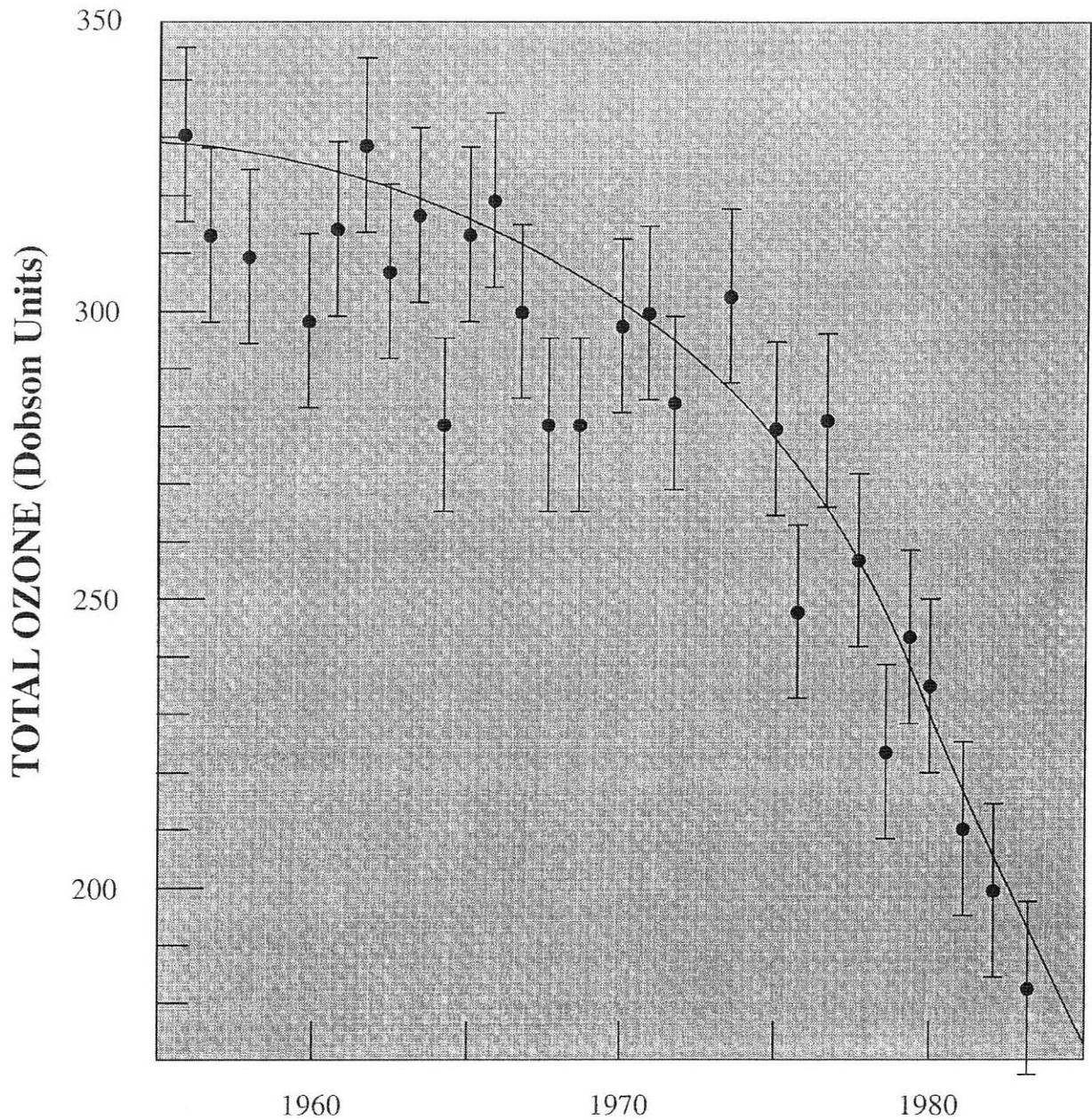
- 1) HEATS ATMOSPHERE, CREATES STRATOSPHERE
- 2) PROTECTS SURFACE FROM MOST U.V.



**Figure 4** Schematic diagram for release of CFC gases at the surface, their photolysis above the ozone layer, and the chlorine chain reaction for removal of ozone.



**Figure 5** Average ozone concentrations above Halley Bay, Antarctica, for the month of October, showing the sharp decline since the mid-1970s. Data of J. Farman and colleagues from British Antarctic Survey.



# Notes

# Population Dynamics of the Zebra Mussel: A Case Study

## OBJECTIVES:

Students will be able to:

1. Discuss the impact that the importation (intended or accidental) of non-native species can have on ecosystems.
2. Discuss the potential impact of Zebra Mussels in Alabama.
3. Estimate the rate of growth of Zebra Mussels from available data.

## BACKGROUND:

Zebra Mussels (scientific name: *Dreissena polymorpha*) are an exotic, introduced species. They look like small clams with wavy, zebra-like black or brown and cream-colored stripes. The mollusks are native to the Caspian Sea in Eastern Europe. It is believed that Zebra Mussels came to North America in the middle of the 1980s as “stowaways” in the ballast water of ships and oceanliners. Since their appearance, first in Lake St. Clair near Detroit, Michigan, Zebra Mussels have created serious ecological as well as economic damage. As Zebra Mussels “colonize,” they accumulate in large masses. These can ultimately block a pipe designed to take water out of a lake or river or force other species out of an area. About the only positive thing the Zebra Mussel has done for the environment in the United States, is that, in areas infested with the Zebra Mussel, the filtering action of the mollusk cleans the water so that the water quality itself may be better than in non-infested areas.

Zebra Mussels cluster in large colonies, up to several hundred per square foot. They can attach to almost any firm surface by using a tuft of fibers called *byssal threads*. These threads act like “Superglue” and allow the mussel to attach to solid underwater objects such as boat hulls and propellers, buoys, clam and turtle shells, drinking water plant intake structures, and industrial pipes and condensers. The adult Zebra Mussel can grow to a length of two inches and can survive for up to five years. Zebra Mussels reproduce rapidly. Females can bear from 10,000 to 1,000,000 eggs per year. The fertilized eggs develop into free-floating larvae that can travel great distances during the next 10-30 days, thus spreading in freshwater lakes or streams. After 30 days, they settle and attach to a suitable hard surface. Zebra Mussels have no natural enemies in the waters of the United States. They, therefore, are extremely difficult to control. The use of chemicals is often the only way to prevent damage from the Zebra Mussel.

## VOCABULARY:

Zebra Mussel, population, Caspian Sea, colonies, byssal threads, larvae, ballast water, exotic species, mollusks

## PROCEDURE:

1. Assume a Zebra Mussel has hatched as a free-floating larvae in the Tennessee River. It floats freely in the river for 15 days and attaches on a barge hull that is moved to the Tennessee/Tombigbee Waterway and is used in that waterway. (See Legacy’s Alabama Water Resources poster.) The barge stays for a year until the following summer when the barge is moved to travel on the Alabama River. If the Zebra Mussel bore eggs once during the year that the barge stayed in the Tennessee/Tombigbee Waterway, what is the estimated population of the Zebra Mussel after five years in the Tennessee/Tombigbee Waterway, assuming that only one Zebra Mussel arrived there originally, that all eggs survived, and that the mussel takes one year to reach sexual maturity?

### Grades:

9-12

### Subjects:

Biology, Ecology, Physical Science, Math

### Time Needed:

30 minutes

### Materials:

a map of Alabama showing the major waterways as well as the Gulf of Mexico (1cm=32km)

2. Why is it a poor assumption that all eggs survive?
3. How many Zebra Mussels could cover a football field in a single layer, assuming a population of 700 Zebra Mussels per square foot? (Assuming one football field = 100 yards x 30 yards, 3 feet = 1 yard.)
4. Once the single Zebra Mussel is in the Tennessee/Tombigbee Waterway and travels on a boat moving at the speed of 15 km/hr, how long will it take to reach the mouth of Mobile Bay? Scale on map: 1 in. = 60 miles.
5. Name some ways to prevent the spread of the Zebra Mussel from the Tennessee River to other Alabama water bodies.

### ANSWERS TO THE QUESTIONS:

1. See below:
  - First year sexually immature.
  - Second year: 10,000–1,000,000
  - Third year:  $1 \times 10^4 \times 10^4 = 1 \times 10^8$
  - Fourth year:  $1 \times 10^8 \times 10^8 = 1 \times 10^{16}$
  - Fifth year:  $1 \times 10^{16} \times 10^{16} = 1 \times 10^{32}$
2. Some will die or be eaten.
3. 100 yds. x 30 yds. = 3000 sq. yds. x 9 sq. ft. = 27,000 sq. ft. x 700 per foot = 18,900,000 mussels
4. Approximately 14 hours (Distance is about 200 km ÷ 15 = 13.3 hr.)
5. Explain the concept of natural predators; non-chemical treatments such as ultra-violet radiation, electrostatic fields, temperature, and magnetic treatments; and surface protection such as non-fouling coatings.

### EVALUATION:

1. The teacher can evaluate on the basis of participation and correct answering of the questions.

### EXTENSIONS:

1. Have the students do research on the spread of the Zebra Mussel in Alabama. This could be an ongoing project.
2. Have the students do research on other exotics such as kudzu, starling, pheasants, and nutria that have been introduced into Alabama.

### ORIGINAL DEVELOPMENT RESOURCES:

“Alabama Water Resources ” poster, Legacy, Inc. P.O. Box 3813, Montgomery, AL 36109, [www.legacyenvd.org](http://www.legacyenvd.org), 1-800-240-5115.

Water Impacts. (1996, January). *Institute of Water Research, Michigan State University*, 17(1).

Website: [www.iwr.msu.edu](http://www.iwr.msu.edu)

<http://www.outdooralabama.com/watchable-wildlife/what/inverts/mollusks/mussels/list/v/z/>

<http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=5>

## OBJECTIVES:

Students will be able to:

1. Categorize marine organisms based on mode of life, habitats, and light zones.
2. Design a model of the marine environment on graph paper illustrating categories of marine life, distribution of marine life as related to habitats, and light zones.
3. Illustrate the vocabulary terms by showing their relationships effectively on graph paper.

## BACKGROUND:

The marine environment can be studied in areas that include the marine organisms and the habitats in which they interact. Classification can be based on mode of life, distribution as related to the sea bottom and ocean water, and division of marine life distribution as related to light penetration. This ecosystem should be viewed in its entirety in order for these relationships to be appreciated.

Classification of marine life *as related to mode of life* includes three great categories. **Plankton** consists of communities of floating, drifting organisms carried about primarily by the movement of water rather than by their own swimming activity. The bulk of these organisms consists mostly of microscopic plants and animals that vary from bacteria to minute yellowish microscopic plants called coccolithophores to copepods several millimeters in length. Many invertebrate larval stages can be found. Larger drifters, such as Sargassum weed and jellyfishes, are present. **Benthos** includes organisms that live on or in the bottom of the ocean floor. They may be demersal organisms, like flounder and certain scallops, that alternate between swimming near and resting on the bottom. Epifauna, such as the seastar, sea anemone, and mussel, live on the substrate. Tube worms and clams are identified as infauna because they live within the substrate. **Nekton** includes larger animals that control the direction and speed of their own movements rather than drifting with the water. This group includes mainly of fish, whales, seals, sea turtles, and a few invertebrates like squid and shrimp.

Classification of marine life distribution *as related to the sea bottom (benthic)* includes the part of the ocean floor beginning from high-tide zone to the greatest depths. The **littoral region** borders continents and extends from high tide out to the edge of the continental shelf (about 200 meters deep). This region is divided into two zones called the eulittoral and sublittoral. The **eulittoral** starts from high tide level to a depth of 40 to 60 meters. This is the lowest limit at which plants will usually grow. This area is characterized by strong tide and wave action. The **sublittoral** extends from 60 to 200 meters deep and the edge is the **continental shelf**. This gentle seaward-sloping surface has an average width of 50 to 100 km. Life found at this level depends on light penetration. The deep sea floor system begins at the edge of the shelf. Extending from the shelf, the **bathyal** goes from 200 to 4000 meters in depth. This bottom may be rocky or muddy. Many organisms vary in color and migrate to the rich upper level at night. The **abyssal** extends from 4000 to 6000 meters in depth. This is a very stable environment with almost no change. Organisms are probably carnivores feeding on the debris that falls from the upper levels. The **hadal** zone goes from 6000 meters to the deepest areas of the ocean floor called trenches. One of the deepest spots recorded is the Marianas Trench near Guam at 36,198 feet (11 km).

## Grades:

9-12

## Subjects:

Science, Marine Science

## Time Needed:

90 minutes

## Materials:

audiovisual of the ocean  
pictures of organisms: plankton,  
benthos, nekton  
graph paper (per student)  
colored pens/pencils

Classification of marine life distribution *as related to the ocean water* includes all water above the ocean floor. The **Pelagic Division** refers to all ocean waters and is divided into the neritic and oceanic provinces. The **neritic province** embraces the open water affected by continental influences. It receives much inland drainage and extends out to the edge of the continental shelf. Included is all the open water within a depth of 200 meters extending shoreward over most of the littoral. The **oceanic province** includes a vertical series of open sea referred to as “blue water.” The **epipelagic** is a relatively thin illuminated zone from the surface to 200 meters in depth. From 200 to 1000 meters, the **mesopelagic** is referred to as the “twilight” zone. The **bathypelagic** begins from 1000 meters and goes to 4000 meters. No solar light may ever penetrate this zone. The **abyssopelagic** continues to the greatest depths. A significant feature of these last three zones is bioluminescence. Ninety-nine percent of higher forms of mid-water marine animals contain photophores. Some examples are squid, anglerfish, viperfish, dragonfish, and hatchet fish.

Classification of marine life distribution *as related to the distribution of light* includes the photic and aphotic zones. The **photic** zone is the place where 70 percent of the world’s photosynthesis takes place. It consists of the **euphotic** that starts at the surface to 80 meters deep and the **disphotic** that goes from 80 to 200 meters in depth (edge of the continental shelf). Most of the light is contained in the euphotic. Few plants are produced in the disphotic that is referred to as the “demarcation line of plant life.” The **aphotic** zone is a lightless region extending from 200 meters to the bottom. No plants are produced, and life is limited. The aphotic occupies over 90 percent of the ocean.

## VOCABULARY:

mode of life, benthos, nekton, plankton, habitat, substrate (ocean floor), littoral, eulittoral, sublittoral, continental shelf, bathyal, abyssal, hadal, habitat (ocean water), pelagic division, neritic province, oceanic province, epipelagic, mesopelagic, bathypelagic, abyssopelagic, light penetration, photic zone, euphotic, disphotic, aphotic zone

## ADVANCE PREPARATION:

1. Introduce the concept of the marine ecosystem.
2. Discuss the types of organisms found and the environmental factors with which they interact.
3. Show pictures of plankton, benthos, and nektonic organisms. Have students describe their living conditions.
4. Show appropriate audiovisuals relating to the ocean environment.

## PROCEDURE:

### *Setting the Stage*

1. Give students an opportunity to acquire information about the terms to be used in the activity by supplying them with the content material directly through lecture or reading material from a text.
2. Identify terms through concept mapping.
3. Show an example of a finished diagram on a transparency, such as the the “Classification of Marine Environments” included with this activity.

### *Activity*

1. Students will illustrate the terms related to the classification of the marine environment by showing their relationships effectively on graph paper. (See example on next page.)
2. Depths on the diagram should be expressed in meters, and terms should correspond to the appropriate depth.
3. Color code each area of terms, for example, Mode of Life—green; Ocean Floor—brown; Ocean Water—blue; and Light Penetration—yellow.
4. Print all words. (Include number with word.)
5. Draw appropriate pictures illustrating mode of life terms (plankton, benthos, nekton). These should be placed at appropriate depths and areas. Label with the appropriate term.

## **EVALUATION:**

1. Have the students label these areas on a prepared diagram (teacher-made).

## **EXTENSIONS:**

1. As a class, design a mural illustrating these areas of the marine environment.
2. Show actual examples of organisms (specimens) and discuss in which areas they may be found.
3. Using an aquarium, design a marine environment relating to the prepared diagram.
4. Research organisms that live deep in the ocean in areas with no light penetration.
5. Research the equipment used to explore the deep ocean.
6. Research hydrothermal vents and the animal life surrounding them.
7. Research the chemical composition of the environment around the hydrothermal vents and compare it with the chemical composition of the rest of the ocean areas.
8. Invite a marine geologist or biologist to talk to the class.

## **ORIGINAL DEVELOPMENT RESOURCES:**

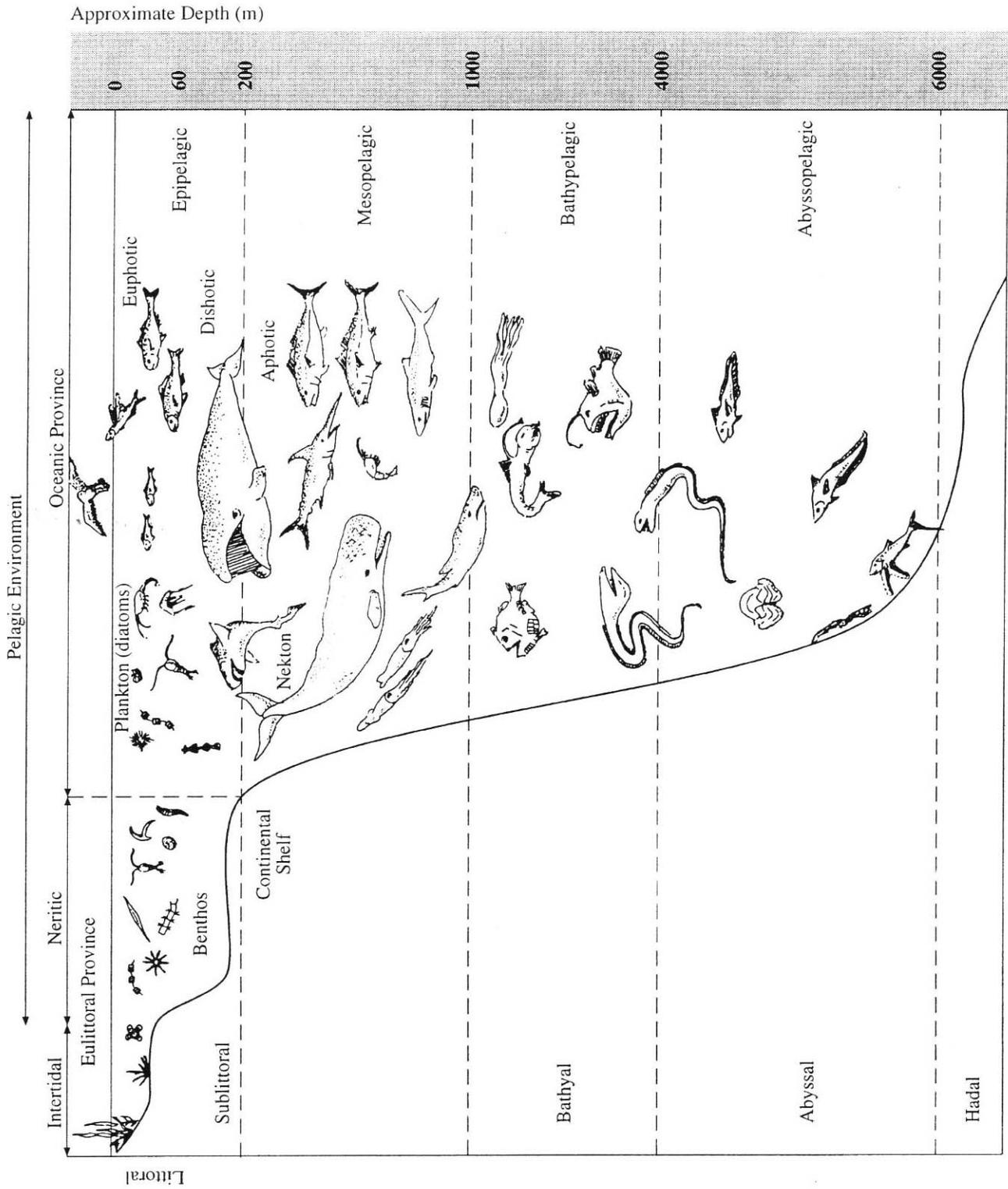
Lerman, M. (1986). *Marine biology*. New York, NY: Addison-Wesley Publishing Co, Inc.

Gross, M. G. (1990). *Oceanography*. Columbus, OH: Prentice Hall.

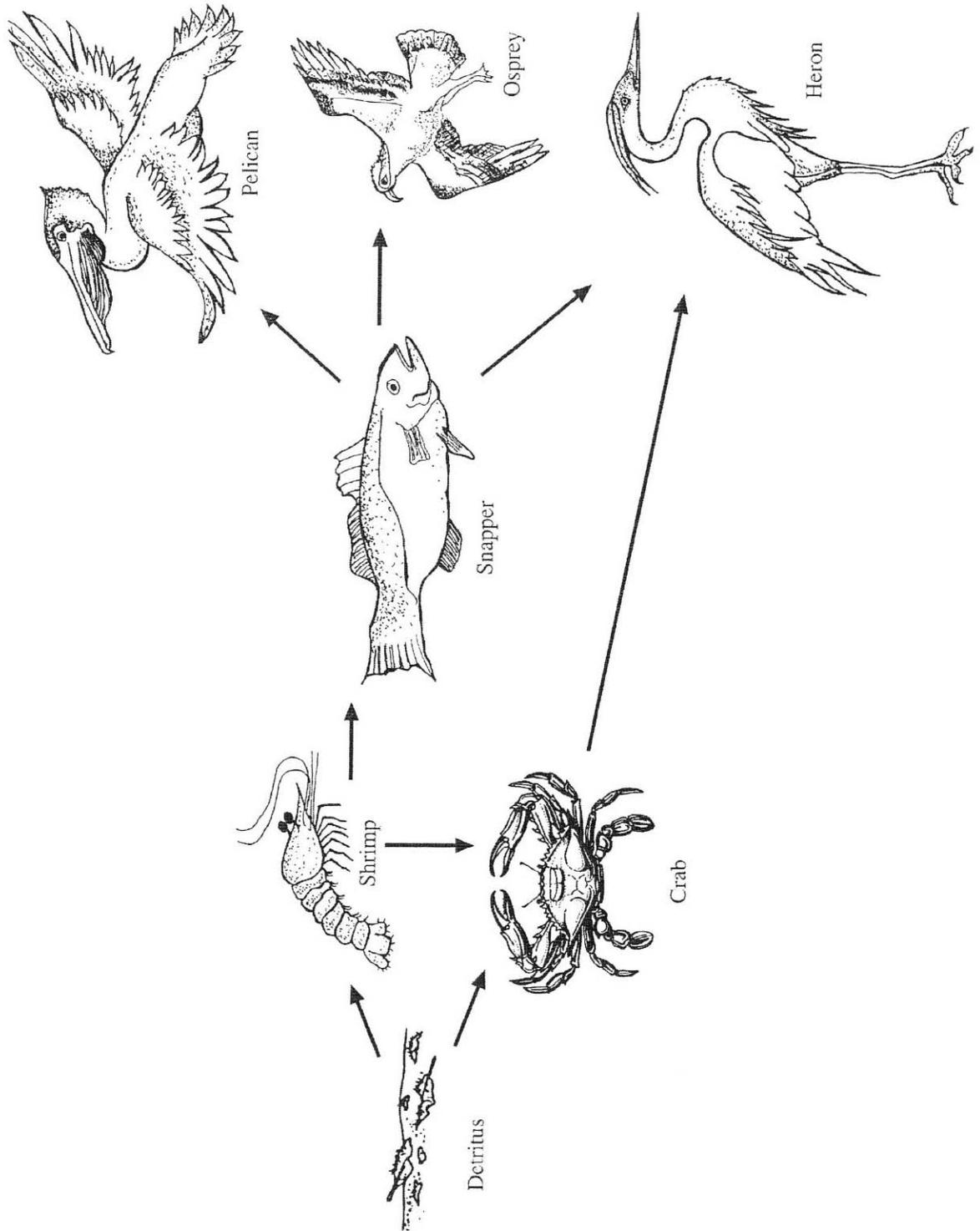
Stowe, K. (1987). *Essentials of ocean science*. Toronto, Canada: John Wiley & Sons.

Websites: [www.disl.org](http://www.disl.org) (Dauphin Island Sea Lab)  
[www.onr.navy.mil/focus/ocean](http://www.onr.navy.mil/focus/ocean)  
<http://fins.actwin.com/index.php> (useful photographs of marine life)  
[www.aquanet.com](http://www.aquanet.com)

# Classification of Marine Environments



# Food Chain



# Notes

# Using Duckweed to Examine Population Dynamics

## OBJECTIVES:

Students will be able to:

1. Measure the increase of duckweed present in a closed ecosystem over a one-month period.
2. Determine the initial number of plants, number of leaves, and biomass of the initial culture of duckweed.
3. Hypothesize the effects of continued, uncontrolled growth of duckweed on the overall sustainability of the environment.

## BACKGROUND:

The ecosystem of a freshwater habitat is dependent on the quality of the water and the ability of the biotic and abiotic factors to remain in balance. Many biological species are capable of reproducing faster than the rate needed to maintain the species number. This ability to reproduce allows organisms to replace a population after natural disasters, disease epidemics, or other population declines.

A population consists of all the members of a particular species occupying a given area. By determining the population of a particular plant, such as duckweed, the health of an ecosystem can be determined. Indicator species, such as duckweed, serve as early warnings that a community or an ecosystem is being damaged.

Duckweed is a rapidly reproducing plant that floats on the surface of the water. The duckweeds belong to the family Lemnaceae. They are the smallest flowering plants known, with the genus *Wolffia* being less than 1.5 mm in size. The body of duckweeds is composed of a simple floating disc of photosynthetic tissue often with roots attached. It is not differentiated into stem and leaf tissue. All species of duckweed supposedly produce minute flowers, but these flowers are seldom observed.

One of the common species of duckweed found floating on the surfaces of shallow ponds is *Lemna minor*. *L. minor* is 2-4 mm in size. Duckweed is an important food for water fowl, fish, and humans. It contains all the essential amino acids needed for growth and is an excellent food for herbivores. The world's smallest flowering plant also has one of the most rapid rates of vegetative reproduction. The Indian species, *Wolffia microscopica*, can produce a smaller daughter plant in its basal reproductive pouch by budding every 30-36 hours. One plant could theoretically give rise to about one nonillion plants (1 followed by 30 zeros) in four months. This represents a spherical volume of plants roughly equal to the size of the Earth. In mid to late summer, ponds often become covered with huge populations of duckweed.

## Grades:

9-12

## Subjects:

Environmental Science, Math

## Time Needed:

First day: 45 minutes

Data collection : 25 minutes once a week for four weeks

Analysis and discussion: 45 minutes

## Materials:

duckweed culture sufficient for groups of four to six (sold by Carolina Biological Supply - or similar supply houses - as *Lemna minor*, listed under floating plants)

containers, such as one-gallon milk cartons or other small containers or aquariums for each group  
fresh, dechlorinated water for each container

student data sheet for each student

balance for measuring mass

hand lens for observing the plants

## **VOCABULARY:**

population, biomass, indicator species, sustainability, biotic factors, abiotic factors, ecosystem, habitat, limiting factors, population density

## **ADVANCE PREPARATION:**

1. Order duckweed (*Lemna sp*) from a biological supply house or collect samples from lakes or ponds. Local universities often can supply small quantities.
2. Prepare an appropriately-sized aquarium and allow to filter with dechlorinated water several days prior to beginning the laboratory. Small cartons or other similar containers can be used in place of an aquarium.  
**Caution:** Do not run filter while plants are in aquarium.

## **PROCEDURE:**

### *Setting the Stage*

1. Have students write a hypothesis stating what changes in population will occur in the duckweed over a four-week period and write the hypothesis on the student worksheet.
2. Discuss the possible effects of overpopulation in the duckweed culture.

### *Activity*

1. Divide the class into groups of four to six students. Each group is responsible for one culture of duckweed. Provide each group with an initial culture of 25 plants (or have each group count out 25 plants). Each group will measure the mass of the 25 plants, count the number of leaves, and describe the overall appearance of the culture. This data is then recorded on the data sheet.
2. Discuss the variables that can affect the changes in growth and overall appearance during the four-week period. List all the variables on the worksheet.
3. Data will be collected by each group at the end of each week for a four-week period.
4. Each group will analyze the data collected by determining the increase in number of plants, number of leaves, and overall mass of the culture.
5. Each group will discuss the data collected and will present a final report to the class.

### *Follow-Up*

1. The class will discuss the data collected by each group and hypothesize how the population will increase over a longer period of time if given optimum growth conditions.
2. Have the students research the effects of overpopulation on a different species of organism and report to the class.

## **EVALUATION:**

1. The students will fill out the Student Data Sheet to be discussed with the class.

## **EXTENSIONS:**

1. Assign each group a varied amount of nutrient fertilizer to be used in the duckweed culture.
2. Provide various types of pollutants and determine the effects on the duckweed population. After a period of time, test the water to see if the duckweed cleaned any pollutants from the water.
3. Ask the students to design an experiment to test the various effects of chemicals, fertilizers, light, warmth, or other variables on the duckweed population.
4. Graph all data collected from the class on graph paper and display for future reference.

## **ORIGINAL DEVELOPMENT RESOURCES:**

Cadogan, A. & Best, G. (1992). *Environment and ecology*. Glasgow: Blackie & Sons, Ltd.

Radford, A. E., Ahles, H. E., & Bell, R. C. (1968). *Manual of the vascular flora of the Carolinas*. Chapel Hill, NC: The University of North Carolina Press.

Towle, A. (1989). *Modern biology*. Austin, TX: Holt, Rinehart, and Winston.

Carolina Biological Science and Math Catalog 66, 2700 York Rd, Burlington, NC 27215, (800) 334 5551, [www.carolina.com](http://www.carolina.com).

# Student Data Sheet

Name: \_\_\_\_\_

## Using Duckweed to Examine Population Dynamics

1. Write a hypothesis stating what changes will take place in the population density of the duckweed culture over the one-month period.

---

2. Record the data collected by your group. Each member of the group is responsible for recording all data on the data sheet.

Date	# of Plants	# of Leaves	Biomass	Appearance
Initial				
Week 1				
Week 2				
Week 3				
Week 4				
Percent Change				

3. Describe what changes occurred over the four-week period.

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4. Was your hypothesis correct? Explain.

---

5. Predict the number of duckweed plants that would be produced over a longer period of time (two months, six months, or longer).

---

6. If uncontrolled growth were allowed to continue, what might happen to the population?

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7. How might uncontrolled population growth affect the quality of life for other species such as humans? Explain.

---

8. How did the data from the other groups compare with the data collected in your group? Explain.

---

## OBJECTIVES:

Students will be able to:

1. Observe how different soil components—peat, sand, gravel, and potting soil—vary in their capacity to absorb and hold water.
2. Describe why peat is exceptional at absorbing large quantities of water.
3. Describe how wetlands affect their daily lives.
4. Explain the importance of wetlands for wildlife and humans.

## BACKGROUND:

Wetlands traditionally have received a “bad rap”—they have been thought of as wastelands, as buggy, mucky places fit only for monsters and other unsavory creatures. Wetlands perform a number of critical functions. They moderate impacts from flooding, control erosion, purify water, and provide habitat for fish and wildlife. They also provide a unique natural habitat for people to enjoy outdoor recreational activities.

Wetlands located along the shores of oceans, lakes, rivers, and streams protect surrounding properties from flooding by acting as a “sponge,” temporarily storing flood water and slowly releasing it back into the system. As storm water enters a wetland from surface runoff or adjacent water bodies, it is slowed down by trees, shrubs, reeds, rushes, and other wetland plants. Slowing the flow of water allows more time for it to percolate through the soil rather than going directly into the water body. Wetlands also act as large sinks, diffusing large flows over a greater land area and slowing the momentum of rushing water. In this way, wetlands help protect adjacent and downstream property from flood damage.

During a storm, the effects of rushing water can be destructive. Rapidly flowing water can carry a large load of soil particles from the land, which are then washed into lakes, rivers, and streams. Excessive sediment in water is considered both a chemical and physical pollutant; it can carry bacteria and toxic particles and alter the habitat of the receiving water for plants and animals. Wetland vegetation reduces the erosive effect of rushing water by slowing the velocity of floodwaters. Coastal wetlands protect shorelines from erosion by dissipating the energy from waves and currents.

Wetlands are good water filters because of their location between land and open water. This allows them to intercept and eliminate many pollutants before the water enters rivers, streams, and lakes. However, wetlands alone can’t solve pollution problems since every wetland has a limited capacity to absorb nutrients, metals, and sediments.

Water flowing into wetlands slows down as it comes into contact with wetland vegetation. Suspended soil particles or sediments will settle out of the water and will bind to the stems and roots of plants. Wetlands play a role in trapping excess sediments and preventing them from entering river and lake systems. Research has shown that as much as 90 percent of sediments in water can be removed as it moves through wetlands.

## Grades:

9-12

## Subjects:

Science, Ecology

## Time Needed:

two to three class periods

## Materials:

peat moss  
sand  
gravel  
potting soil  
several sieves  
cheesecloth or coffee filters  
measuring cups  
bowls for catching water  
scales  
student data sheets  
pictures, photographs, or slides of wetlands

## **VOCABULARY:**

erosion, estuary, purification, runoff, sediment, wetland

## **ADVANCE PREPARATION:**

1. Show magazine pictures, slides, and photographs of wetland areas.
2. Show pictures, slides, and photographs of different wetland soil types (good ones on EPA's web site: [www.epa.gov/owowwtr1/](http://www.epa.gov/owowwtr1/) - look for wetlands photo contest).
3. Have students find an area in their neighborhood, city, or town that they suspect is a wetland area. Have them collect (with permission) a few wetland soil samples and bring them to class. Have students describe in their own words how their soil sample looks, feels, and smells.
4. Arrange a classroom display of the collected soil samples. Have the students attempt to identify the different types of soil.
5. Discuss the importance of wetlands to the health of our planet. Have the students brainstorm the benefits of wetlands and the reasons they are important. List the ideas on the chalkboard.

## **PROCEDURE:**

### *Setting the Stage*

1. Read the background information on wetlands, focusing on the many benefits we get from wetlands. Emphasize the fact that one important benefit of wetlands is the capacity to absorb large amounts of water during rainstorms and to release it slowly over time into rivers, lakes, and groundwater. This function prevents extreme flooding during storms and maintains a base level of water during dry spells. This water storage capacity is due in part to the presence of organic matter in wetland soils.

### *Activity*

1. Divide the class into cooperative groups.
2. Give each group four sieves and a dry sample of each of the purchased soil types (peat, potting soil, sand, gravel). Put samples in the bowls and place cheesecloth or a filter in each sieve and fill each with a different soil type.
3. Have the students weigh out the filled sieve with the bowl on a scale and record this on the student data sheet.
4. Instruct the students to fill the measuring cup with exactly one cup of water. Pour the water into the sieve and let it soak in the bowl for 30 minutes. Do this for each bowl with soil types.
5. Lift the sieve out and slowly pour the remaining water out of the bowl. Have the students reweigh the sieve, wet material, and bowl and record the weight on the Student Data Sheet.
6. Using the Flood Storage Data Sheet, have students calculate the percent of water absorbed by each material by subtracting the dry weight (A) from the wet weight (B) to yield (C).  $C/A \times 100 =$  water absorbed. Have each group record its results on the chalkboard and discuss the results. Have the students prepare graphs of their results.
7. Have the students discuss the following questions:
  - Which of the materials—peat, soil, sand, or gravel—retained the most water?
  - What factors influence a soil's capacity to hold or drain water?
  - What determines how much water a substance can hold?
  - What would happen to rain water if there were mainly poorly absorbing soil types in the watershed?

### *Follow-Up*

1. Have the students look through newspapers for articles about flooding. Have them do a comparison study to see if any of the flooding was related to wetland loss.
2. Prepare a classroom display of commercial products harvested from wetlands.

### **EVALUATION:**

1. Have the students write an opinion paper on how our lives are linked to the health of the environment.
2. In the paper, have the students focus on what would happen if wetlands disappeared.

### **EXTENSIONS:**

1. Hold a mock town meeting where students take the roles of neighbors, developers, town officials, and environmentalists to discuss options involved in a proposed development project impacting wetlands.
2. Have students develop a “wetland protection directory” of local, state, and federal officials who make land use decisions affecting wetlands.

### **ORIGINAL DEVELOPMENT RESOURCES:**

Lynn, B. (1988). *Discover wetlands: A curriculum guide*. Washington State Department of Ecology.  
<http://www.epa.gov/gmpo/education/pdfs/DiscoverWetlandsI.pdf>

National Wildlife Federation, (1986). *Ranger Rick's naturescope: Wading into wetlands*. Washington, D.C., Vol. 2, No. 5. [www.nwf.org](http://www.nwf.org)

Slatterly, B. (1995). *WOW! The wonder of wetlands: An educator's guide*. St. Michaels, MD: Environmental Concern, Inc.; [www.wetland.org](http://www.wetland.org).

[http://water.epa.gov/type/wetlands/outreach/education\\_index.cfm](http://water.epa.gov/type/wetlands/outreach/education_index.cfm)

## Flood Storage Data Sheet

Name: \_\_\_\_\_ Date: \_\_\_\_\_

<b>Material</b>	<b>Dry Weight</b>	<b>Wet Weight</b>	<b>B-A=C</b>	<b>Percent (%) water absorbed = <math>(C/A) \times 100</math></b>
<i>Peat</i>				
<i>Soil</i>				
<i>Sand</i>				
<i>Gravel</i>				

## OBJECTIVES:

Students will be able to:

1. Describe the concept of a watershed.
2. Explain how wetlands function within a watershed.
3. Illustrate how human impacts can alter wetlands.

## BACKGROUND:

Did you know that every state in the United States has at least one “wetland” in it? (See Figure 1.) You’ve probably even visited one, or at least seen one, as you rode down the highway!

Wetlands are part of our lives, and that’s a great reason to start learning all you can about them. Wetlands are often referred to as swamps, bogs, moors, fens, and marshes. Wetlands are often transitional areas located between dry lands and deeper aquatic systems like rivers and lakes. Wetlands can be shallow water habitats, where the soil is covered by water, or saturated areas, where the soil is wet at or near the surface but not necessarily covered by water.

Some wetlands develop in low-lying areas in the landscape where water drains and collects. Others border salt or fresh bodies of water such as oceans, rivers, or ponds; while still others are isolated in forests and urban areas. As the transitional zones between upland and aquatic areas, wetlands often support both terrestrial and aquatic species, contributing to the diversity of plants and animals they support.

Wetlands vary considerably in their appearance and size. Regional and local differences in vegetation, hydrology, water chemistry, soils, topography, and climate contribute to the variety of wetland types found around the world. Some wetlands are inundated with water year round, while others are only seasonally flooded; and the depth and duration of flooding can vary widely. Still others are only saturated at or near the surface of the soil. Wetlands may occupy just a few hundred square feet or may cover thousands of acres.

Why are wetlands valuable?

- flood control and traps for sediments
- storm protection
- temporary homes for migrating birds
- homes and nesting sites for animals, fish, and birds (including 1/3 of America’s threatened and endangered wildlife) and specialized plants
- water purification
- source of economic income
- recreation sites for humans

Now our wetlands are disappearing. We lose approximately 300,000 acres every year, at a rate of over 32 acres per hour.

## Grades:

9-12

## Subjects:

Science, Ecology

## Time Needed:

90 minutes

## Materials:

10-gallon aquariums or clear basins  
spray bottle with water  
newspaper  
waterproof magic markers  
plastic sheets  
miniature houses (game pieces)  
pictures of different types of wetlands  
United States and Alabama maps  
showing wetland areas  
potting soil, peat, sand, clay

## **VOCABULARY:**

hydrology, infiltrate, percolate, precipitation, watershed, wetland

## **ADVANCE PREPARATION:**

1. Introduce the terms hydrology, infiltrate, percolate, watershed, and wetland.
2. Show the students a U.S. map indicating areas designated as wetlands.
3. Show the students a map of Alabama indicating areas designated as wetlands.
4. Show the students magazine pictures, photographs, and slides of various types of wetlands.
5. Have the students make comparison maps showing U.S. wetland areas in 1780 compared to 2002.
6. Have the students design a wetland display, either a mural or a three-dimensional one for the classroom, showing the importance of wetlands to the health of our planet.

## **PROCEDURE:**

### *Setting the Stage*

1. Read the background information on the characteristics of wetlands. Have the students brainstorm where the water in wetlands comes from and why it is important.
2. Have the students prepare a “wetland” journal recording each day’s activities relating to wetlands. Ask them how they use water in their daily lives. Also, have them record how much water they use in one day’s time. Compare the class results and list on the chalkboard.
3. Using the responses above, have the students discuss where the water originated (a well, a town reservoir, a river, rain water) and where it goes (to septic tanks and waste water treatment plants). Emphasize the importance of water and how our uses impact upon its quality and quantity.
4. Discuss that water is always moving from high areas to low areas due to gravity. Any piece of land belongs to a very small watershed that is part of a much larger watershed.

### *Activity*

1. Have students experiment with the movement of water through different gradients by constructing terrariums using potting soil, peat, rocks, sand, and clay. Have each group of students build the most absorbent, the most erosive, and the fastest draining gradients through which the water might travel.
2. To demonstrate and illustrate watersheds and the effects that changes in land use have on watershed areas, students will build a watershed model (see Figure 2) using the following procedure:
  - Divide the class into cooperative groups and give each group a 10-gallon aquarium or a clear plastic basin and the necessary supplies.
  - Have the students crumple three sheets of newspaper and place them in the aquarium. Drape the plastic sheet over the paper, fitting it between the three pieces to form two valleys with a ridge in the middle. Tape the plastic to the walls of the aquarium to prevent water from running down the sides. The water should generally flow towards the valleys and the front side of the aquarium.
  - The students should now have a model of three hills and two valleys.
  - Ask the students to describe what they think will happen when it “rains.” Have them draw a channel through the valleys on the plastic sheet, placing a few of the houses alongside the river. Have the students color in a lake where they expect the water to pool.
  - The students should gently spray some water into one half of the aquarium so that only one of the two watersheds gets wet. Point out how the water runs off the high points and forms a stream in the valley. This is how rain and melted snow run off the land. Explain to students that all of the land that drains into a stream is called a watershed.
  - Have the students spray water so it hits the ridge between the two valleys. Some of the water will run into one stream, and some will run into the other. The ridge between these streams is called the watershed divide. It’s the highest point of land between two bodies of water.

*Follow-Up*

1. Talk about the Continental Divide in the Rocky Mountains, where water to the west flows toward the Pacific Ocean and to the east toward the Atlantic Ocean.
2. Tour a wetland site and observe the topography.

**EXTENSIONS:**

1. Invite a Water Department or Board of Health officer to visit the class for a discussion on drinking water.
2. Manipulate the Wetland Watershed Model to demonstrate how human impacts alter watersheds.
3. Have the students participate in the Adopt-a-Wetland Program. Contact the regional Environmental Protection Agency office in the area for information.

**ORIGINAL DEVELOPMENT RESOURCES:**

(1987). *Aquatic project wild*. Western Regional Environmental Education Council.

Lynn, B. (1988). *Discover wetlands: A curriculum guide*. Washington State Department of Ecology.

National Wildlife Federation. (1992). *Ranger Rick's naturescope: wading into wetlands*. Washington, D.C., Vol. 2, No. 5. (available to order on-line at [www.nwf.org](http://www.nwf.org)).

River Network (1994). *Starting up: a handbook for new river and watershed organizations*: Portland, OR. (available through [www.rivernetwork.org](http://www.rivernetwork.org).)

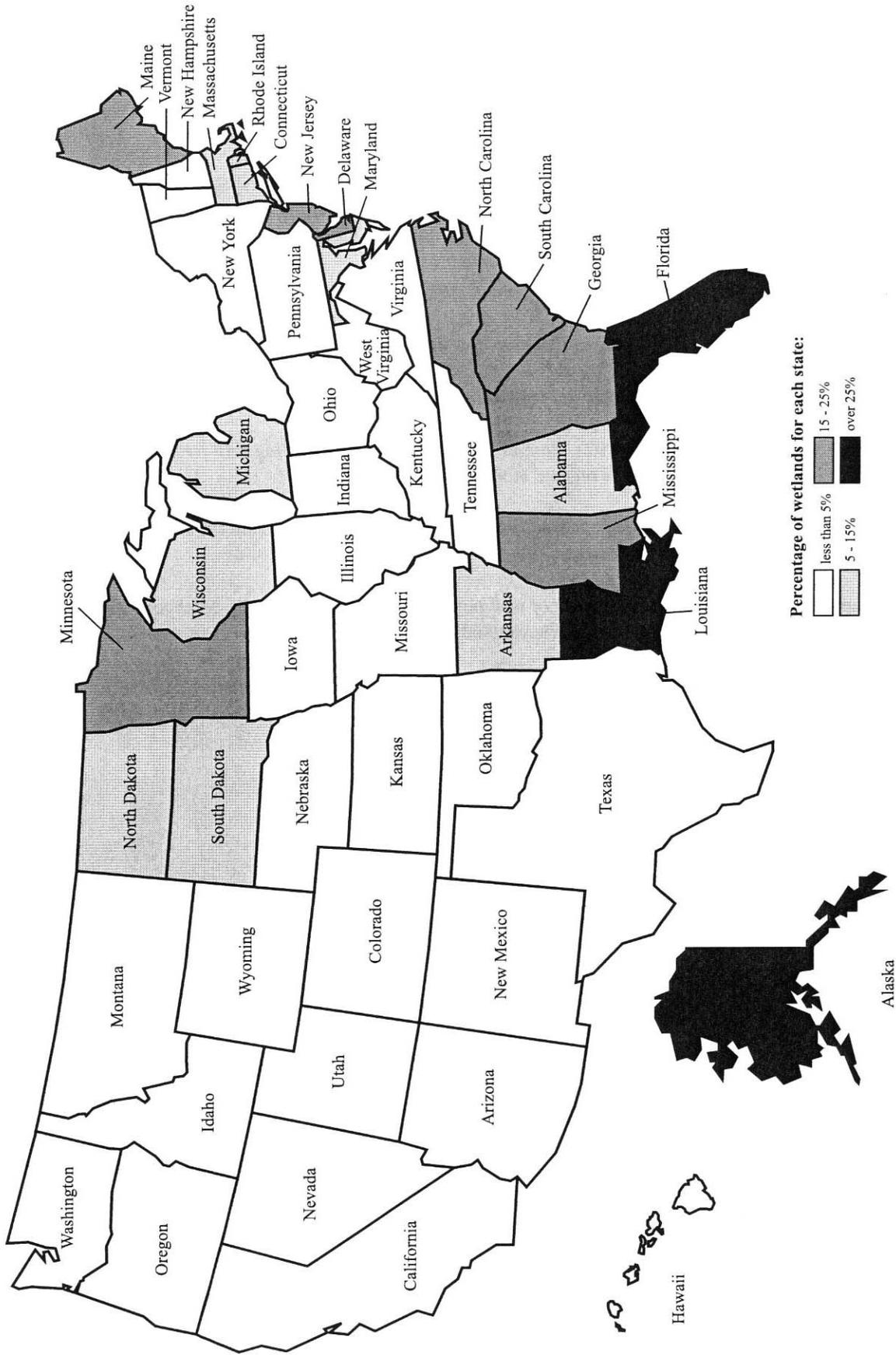
Slatterly, B. (1995). *WOW! The wonder of wetlands: An educator's guide*. St. Michaels, MD: Environmental Concern, Inc.; web site: [www.wetland.org](http://www.wetland.org)

Websites with information about wetlands and watersheds:

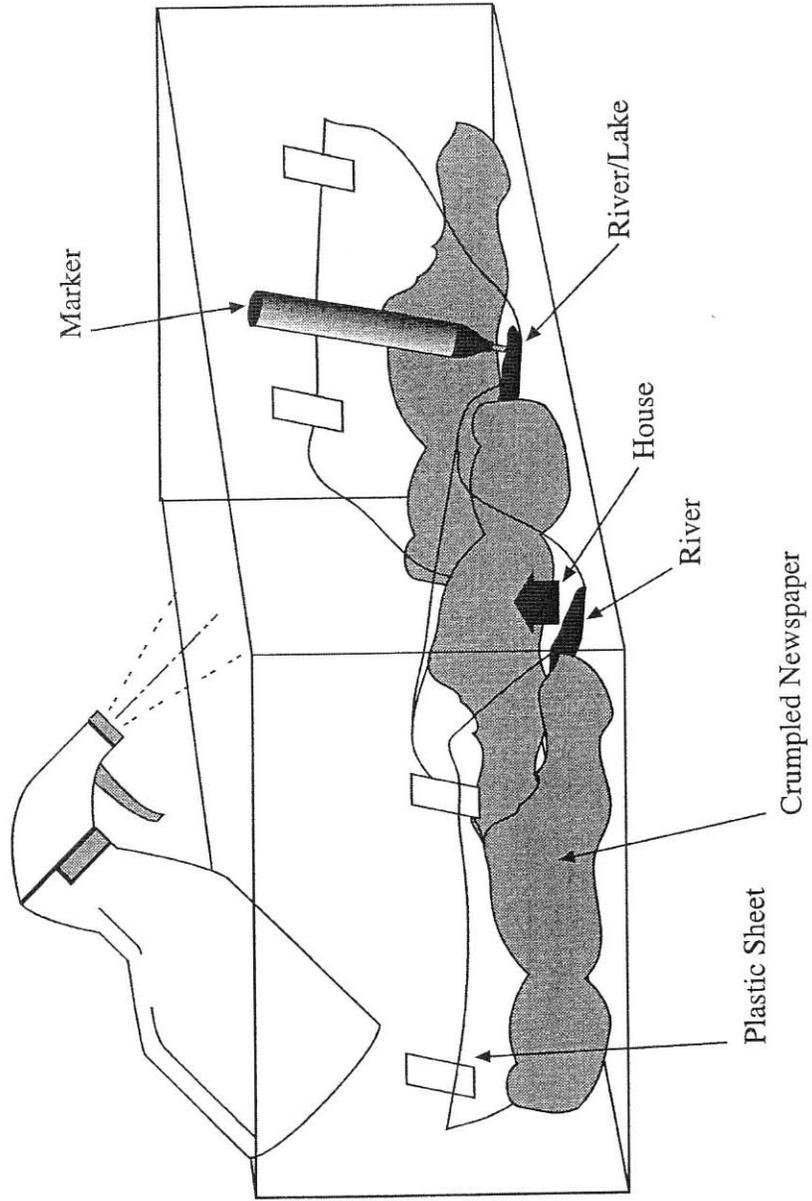
[www.wetmaap.org](http://www.wetmaap.org) (includes slide show)

[www.ducks.org](http://www.ducks.org)

[www.nwf.org](http://www.nwf.org)



# Watershed Model



# Notes