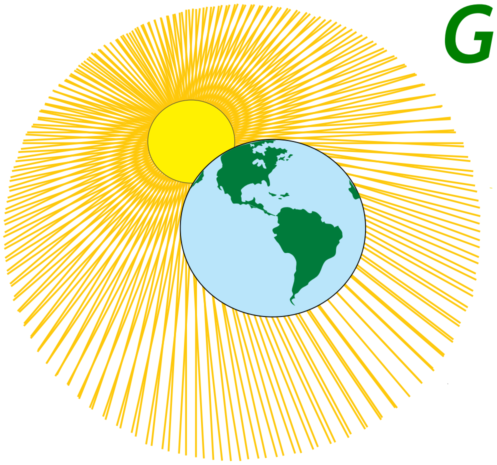
Lawrence Hall of Science



# Global Systems Science

# A New World View
## Teacher's Guide

by Cary Sneider, Richard Golden,
Katharine Barrett

## Contents

**Strategies for Computer Use** .......... **3**
**Teaching Objectives** .......... **4**
**Assessment Tasks** .......... **5**
A New World View—Questionnaire .......... 7
A New World View—Concept Map .......... 8
What Does the Drawing Mean? .......... 9
**Page-By-Page Suggestions** .......... **10**
Chapter 1: What Is Global Systems Science? .......... 10
Chapter 2: A History of Forest Use in the Pacific Northwest.... 14
Chapter 3: Case Study: The Headwaters Controversy .......... 15
Chapter 4: Field Trip to Wind River .......... 16
Chapter 5: Losing Tropical Rainforests .......... 18
Chapter 6: Towards a Sustainable World .......... 19
**Resources for Teaching A New World View** .......... **21**
**Bibliography for A New World View** .......... **26**

## Sources of Support

**NIGEC.** Development and publication of the Global Systems Science (GSS) series was supported by the Office of Science, Biological and Environmental Research Program (BER), U.S. Department of Energy, through the Western Regional Center of the National Institute for Global Environmental Change (NIGEC) under Cooperative Agreement No. DE-FC03-90ER61010. Noreen Dowling, Joseph Knox, Linda Ono, and Thomas Suchanek provided assistance to this project on behalf of NIGEC and WESTGEC.

**NSF.** The opportunity to involve high school teachers in the development of this project was made possible by a grant from the Teacher Enhancement Program of the National Science Foundation (Grant #TPE 9155393). This grant enabled us to invite 125 teachers to test these materials with their students, then come to Berkeley for three weeks, where they reported on trial test results, suggested improvements in the printed materials, and developed new laboratory activities. We are indebted to Larry G. Enochs and Wayne Sukow, Program Directors of the National Science Foundation, as well as to many teachers and students whose insights, ideas, and hard work have helped bring the GSS series to fruition.

**NASA.** Printing and distribution of the GSS Guides is courtesy of NASA's Earth Science Enterprise (ESE), under a Memorandum of Understanding between NASA and the University of California at Berkeley. Nahid Khazenie provided assistance on behalf of NASA/ESE. The purpose of this agreement is to provide the broadest possible distribution to high schools throughout the United States at the lowest possible cost.

Financial support does not constitute an endorsement by DOE, NSF, or NASA of the views expressed in this book.

To obtain latest revised editions of GSS books through University of California, Lawrence Hall of Science, please visit the GSS website:

*http://www.lawrencehallofscience.org/gss/*



Global Systems Science is an activity of the Lawrence Hall of Science, University of California, Berkeley. The director of the Lawrence Hall of Science is Ian Carmichael.

GSS is also an activity of the Museum of Science in Boston, Massachusetts, which provides assistance in revising and disseminating the program. The President and Director of the Museum of Science is David W. Ellis.

# The Global Systems Science Series

*Global Systems Science* (GSS) is an interdisciplinary course for high school students that emphasizes how scientists from a wide variety of fields work together to understand significant problems of global impact. The *Teacher's Guide to Global Systems Science* provides an overview of the entire series and makes recommendations for how a course in this subject can be structured and presented. It is strongly recommended that teachers consult that guide before beginning a GSS course for their students.

*The Teachers' Guide to GSS* suggests that every course using this series begin with the unit *A New World View*, which introduces the entire field of global systems science, and presents four key ideas that thread through the entire series: First, the Earth has tremendously diverse environments, yet it is a single planet that we all call "home." Second, we can better understand the Earth if we think of it in terms of systems. Third, everything is connected to everything else. And fourth, the goal of global studies is to find out what we can do to sustain life on Planet Earth—now and in the generations to come.

*A New World View* can be followed by any other units in the series, depending on the purpose and context for the entire program. Several alternatives are suggested in the Teacher's Guide to GSS.

# Strategies for Computer Use

GSS has two types of computer/technology aspects:
(1) students can read the materials on computer display, and
(2) some investigations involve using computer software, *Interpreting Digital Images*.

1. For reading GSS books:
   a. For in-class reading, show the reading material with a single classroom computer with large screen display (such as LCD projector) and have all the students read that display. This has a number of advantages such as needing only one computer, option of students reading the material aloud, or having immediate discussions of certain questions that might come up. You can have students silently read a page with the assignment to pick a sentence or two that contains a key idea that is especially interesting to them. Then have volunteers read their chosen sentences and explain why it is of special interest to them.
   b. For reading as homework, you need to find out how many students are able to use a computer at home for doing homework. For those students that have computers at home you can have students take the book home on CD-ROM or access the file from the GSS website. Students who do not have use of computers at home will need either hard copy books or printouts of the specific pages that are the reading assignments.
2. For investigations using software:
   a. Reserve a computer lab and depending on the number of computers available, have one student per computer or pairs/groups of students share computers.
   b. Use a single classroom computer with large screen display. Have students take turns doing the "driving" with the whole class watching and discussing results.
   c. If most students have access to computers at home, assign the investigations as homework and loan CD-ROMs to the students to install the software on their home computers.
   d. Use a combination of any of the above approaches. For example, use strategy (b) for introducing the investigation and then (a) or (c) for student work.

# Teaching Objectives

***A New World View*** introduces all of the other Guides in the *Global Systems Science* series, and presents key ideas that thread through the entire course. To learn about the value of laboratory work for investigating Earth systems, students design and conduct controlled experiments to determine how to sustain life in an aquatic ecosystem. The four goals for the unit *A New World View*, and the objectives which support these goals are summarized on this page.

**Goal 1: Students will consider both the diversity of environments on Earth and its unity.**

Objective 1A: Students are able to "see through the eyes" of an astronaut, and discuss the ways in which the Earth can be viewed as a whole planet, despite the large number of different environments on its surface.

**Goal 2: Students will be introduced to the systems approach to studying the Earth.**

Objective 2A: Students are able to identify the parts of a system and discuss the ways that the parts are related to each other.

Objective 2B: Students can distinguish essential from nonessential parts of a system.

Objective 2C: Students are able to identify subsystems and to explain how any system is part of a larger system.

Objective 2D: Students are able to draw systems diagrams.

Objective 2E: Students are able to identify instances of positive and negative feedback, and describe how they are likely to affect the system over time.

Objective 2F: Students can explain what is meant by the phrase "Everything is connected to everything else."

**Goal 3: Students begin to think about how human actions affect future generations.**

Objective 3A: Students can give examples of how humans are affecting the environment today.

Objective 3B: Students can explain how changes in the environment, which are just beginning to be noticed, may become greater and greater in the years to come.

Objective 3C: Students are able to envision what environmental change will mean to future generations.

**Goal 4: Students realize that the world is a common resource that is shared by all.**

Objective 4A: Students are able to identify potential problems concerning the sharing of global resources.

Objective 4B: Students recognize ways that their personal activities draw on Earth resources.

# Assessment Tasks

**Portfolios.** General ideas for assessing student progress towards the goals and objectives of the GSS course are suggested on pages 19-23 of *The Teacher's Guide.- Overview of the GSS* We especially encourage the use of portfolios as a means of providing feedback to students and to demonstrate evidence of student progress to parents. Portfolios for *A New World View* might include:

- Responses to the questions about the drawing by Chuck Trapkis from the magazine *In Context*.
- An art or writing project describing the environment where each student grew up.
- Systems diagrams.
- Lab report on "Creating Your Own Ecosystem."
- An expanded diagram of the water cycle in a tropical rain forest.
- Diagrams and written descriptions of examples of positive and negative feedback.
- Answers to questions in the box on page 68, entitled: "How would you solve the problem of the commons?"
- A concept map of chapters 2 and 3 of the Student Guide.
- An essay or other form of assignment in response to the challenge "In Your Opinion" on page 69.

In addition to portfolios, we suggest that you use assessment tasks both before and after presenting the unit. The papers that students' complete before beginning the unit will help you diagnose their needs and adjust your plans accordingly. Comparing these papers to the students' responses on the same tasks after completing the unit will allow you to determine how your students' understanding and attitudes have *changed* as a result of instruction. Three tasks which we suggest be used for pre- and post- assessment are as follows:

## 1. Questionnaire

These questions are designed to determine how students' knowledge of key concepts have changed during the unit, and whether or not they have changed their opinions concerning personal actions and environmental issues.

## 2. Concept Map

Asking students to create a concept map before and after the unit is one way to determine which concepts they have learned and their understanding of the connections among these concepts. If students have not had experience in concept mapping, you might want to start them out with a hand-out showing an example (master on p. 8), a general idea of what they are to map, and starting word(s) to help get them started. Once they have had experience with concept maps, they can create them on blank sheets of paper (no photocopying required). Alternatively, they can use concept mapping software such as

Inspiration (http://www.inspiration.com)

Decision Explorer (http://www.banxia.com/dexplore/index.html).

CMap (http://cmap.ihmc.us/conceptmap.html - free for noncommercial use).

Compendium (http://compendium.open.ac.uk/institute/ - free download).

Omnigraffle (http://www.omnigroup.com/applications/omnigraffle Mac OSX)

Freemind (http://freemind.sourceforge.net/wiki/index.php/Main_Page - open source software for mind-mapping.)

Microsoft Draw (comes with Microsoft Office)

Some possible key words to use: systems, global, equilibrium, energy, ecosystem, climate, vegetation, plants, forest, old growth forest, logging, lumber, tree, canopy, foliage, redwood, mushroom, lichen, moss, rainforest, Amazon, environmentalist, extinction, habitat, conservation, sustainable, elodea, experiment, variable, observation, NIGEC, NOAA, endangered species, spotted owl, ecosystem, electromagnetic spectrum, infrared.

## 3. Drawing Interpretation

Students are asked to interpret the drawing by Chuck Trapkis on page 2 of *A New World View*. This is an open-ended question, with no right or wrong answers. Most students interpret the picture as two figures dancing, one representing nature, the other representing science and technology. The purpose of this question is to determine how students' attitudes about the relationship between human activities and natural processes change during the unit.

These three tasks fall along a spectrum from traditional to nontraditional ways of assessing student progress. The Questionnaire is a traditional way to elicit student understanding. It assesses students' abilities to express themselves as well as insights that they gained from the unit. The Concept Map is nonlinear. Students do not need to think in terms of sentences and paragraphs, and their ideas can flow more freely. Students who are more visual might be better able to show what they know on this task than on the Questionnaire. The Drawing Interpretation task is the least traditional of the three. It is designed to elicit students' attitudes towards the relationship between human activities and Earth systems.

## Interpreting Student Responses

The tasks should be interpreted in terms of the objectives listed on page 4. This is straightforward in the case of the questionnaire, where questions correspond to the objectives as follows:

| Goal | Objective | Questionnaire Number |
|---|---|---|
| 1 | 1A | 1 |
| 2 | 2A | 2 |
| | 2B | 2 |
| | 2C | 3a. |
| | 2D | 2 |
| | 2E | 3b., 3c. |
| | 2F | 3d. |
| 3 | 3A | 4 |
| | 3B | 5 |
| | 3C | 5 |
| 4 | 4A | 6 |
| | 4B | 7 |

The Concept Map and Drawing Interpretation tasks are more loosely related to specific objectives. Comparing students' papers before and after instruction may show that they have learned more about some objectives than others, or that certain misconceptions persist while others have been corrected. Eventually, we hope to be able to provide sets of instructions (called "rubrics") to score student papers with respect to course objectives; but we do not yet have enough student data to do this.

In the meantime, we suggest that you pair students' pre-and post-assessment papers and compare them. With the list of objectives in mind, look for changes in the students' attitudes and understanding. As you look through your students' papers, you'll be able to jot comments for individual students concerning main points they may have missed, or praising them for their insights and ideas. After looking over all of the papers you will be able to write down some generalizations about what the class as a whole learned or did not learn during the course.

The three tasks are presented on the following three pages. You may want to make two class sets of each of the tasks, using one color of paper for the pre-assessment measures and a different color of paper for the post-assessment measures.

Name

Date

# A New World View—Questionnaire

Global Systems Science is a new field of study in which many different disciplines are used to understand our planet. Show what you know about this field by answering the following questions. Use another sheet of paper to write your answers.

1. Imagine an astronaut looking at the Earth from space, recalling the many different environments visited in the past—from cold mountains, to moist rain forests, and hot deserts. Name at least three ways in which the astronaut can now see (or think about) how these different environments are related.

2. Think about your classroom as a system. Draw a diagram showing the parts of the system and how they are related to each other. Use arrows to show how information flows through the system.

3. Write a sentence or two showing how each of the following statements relate to your classroom:

   a. Systems contain subsystems and are parts of larger systems.

   b. Negative feedback tends to keep systems stable.

   c. Positive feedback can cause large changes in systems.

   d. Everything is connected to everything else.

4. Name at least three ways in which humans are changing Earth's natural systems.

5. Explain how the changes that you named above will make life different for your grandchildren than it was for you.

6. In your personal opinion, will the sharing of Earth's resources cause problems in the years ahead? Please explain your answer.

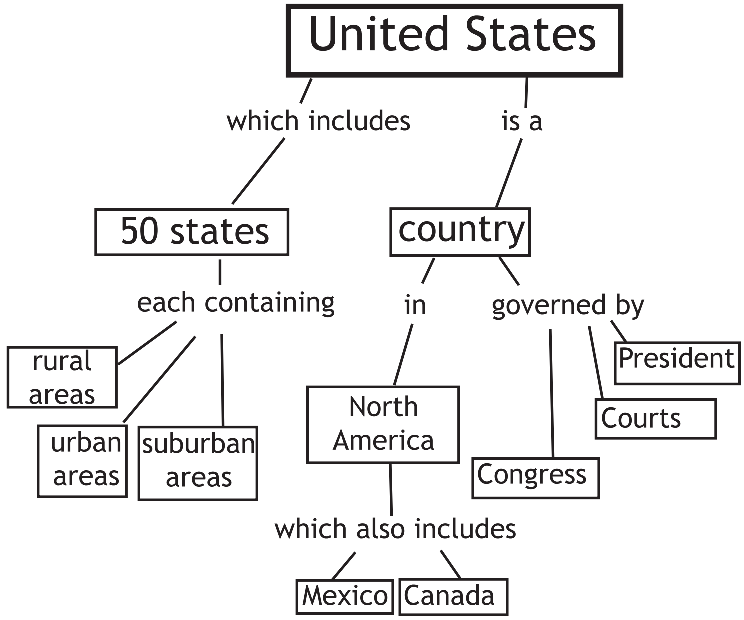
7. Describe one of your own activities that uses up some of Earth's limited resources; and how you could change that activity to use fewer (or no) resources.

Name______________________________________ Date____________________

# A New World View—Concept Map

A concept map is a way of displaying your knowledge about a certain subject area. It consists of a set of words in boxes representing the most important ideas. The boxes are connected by lines and words showing how the ideas in the boxes are related. For example, at right is a concept map about the United States.

Your task is to create a concept map about the Earth. Your concept map should show ways of thinking about the Earth as a system. Start with the word "Earth" at the top. (If you'd like more space, you can draw your concept map on the back, or on another sheet of paper.)




Earth

Name________________________________________ Date______________________

# What Does the Drawing Mean?

1. There are two figures in the picture on this page.
   What do you think the two figures represent?

   __________________________ and ______________________

   Please explain your answer:

2. What do you think the figures are doing?

   ____________________________

   Please explain your answer:

3. In your personal opinion, what is the meaning of this picture in terms of the Earth?

4. If you were to redraw this picture, what changes would you make? Give reasons for your answer.

# Page-By-Page Suggestions

## Before you start

- At least a day or two before you begin *A New World View*, distribute copies of the three assessment tasks on the previous pages and ask your students to answer the questions. Explain that they will not be graded on these. The purpose is for them to show you what they already know so that you can plan the course accordingly.
- Invite students to bring in news clippings about environmental change. Put these on a bulletin board, organized by topic. Relate the articles to class discussions, and make them available for students to use at the end of the unit, when they are asked to identify an article on their choice as the focus of an essay.

# Chapter 1: What Is Global Systems Science?

## Pages 2 and 3

- Give the students a few minutes to read pages 2–3, which introduce the GSS Course. You might ask pairs of students to discuss the questions on page 3 when they finish. These are the same questions that they were asked to respond to on one of the assessment tasks. (Talking about something with one other student for a few minutes generally helps students become more confident, and develop their ideas further).
- When it is clear that everyone is finished reading and has had a few minutes to talk in pairs, you might begin a large group discussion, taking one question at a time. You can encourage shy students by explaining that there is no right or wrong answers to these questions, and that the purpose of the discussion is to share different ideas about the Earth and our relationship to it. This drawing has sparked some wonderful class discussions, according to many of the teachers who tested the GSS course materials, and we suggest you take whatever time is necessary for the students to fully discuss their ideas.

## Page 4

- Point out that page 4 gives an overview of Global Systems Science. You might ask the students to read the page and discuss their impressions of what is meant by the title, *A New World View.*

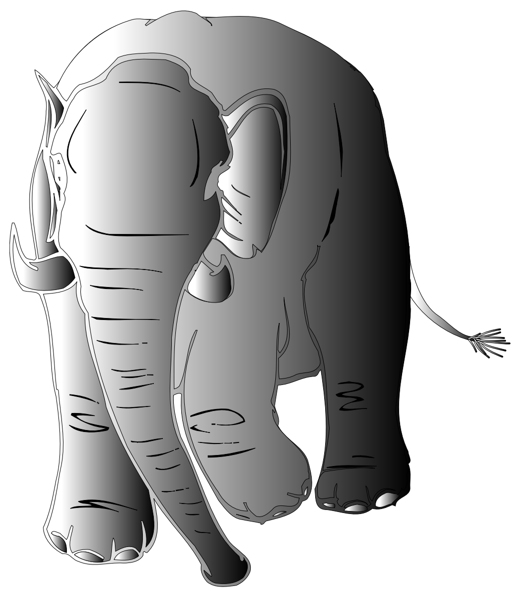
## Page 5 and 6

- The two-page spread on pages 5 and 6 is intended to communicate that because the Earth has many different environments, it is difficult for any individual to grasp the whole.
- We encourage you to try the activity implied on page 6—have students write a paragraph describe their "world," e.g. the school or classroom, and see how the the descriptions differ from each other. Ask the students if there are other situations in which the allegory applies, even in scientific work.
- A good homework assignment associated with these two pages (suggested by Debra Pugh and others) is to have your students complete a writing or art project in which they describe the part of the world where they grew up, or that they know best. If your students come from diverse backgrounds, sharing these in class will give everyone a better understanding of our planet.
- A variation on the above is to exchange essays and drawings with another class of students in a different country or a different part of the United States.

## The Elephant Activity

Adapted by Eloise Farmer from Goldstein, Philip, *How to Do An Experiment*, New York: Harcourt, Brace, and Company, 1957, pp 31-33.

If your students enjoy dramatizations, invite six volunteers to be blind wise men. Assign them numbers from one to six. Tell the class to look at an open space in the classroom and to imagine a giant elephant standing there. You can embellish this with more descriptive words like bristly, wrinkly, grey, swinging trunk, etc. Then read the poem aloud (or have a student volunteer read it). As the poem is read, the student representing each blind wise man goes to the invisible elephant and acts out his or her part. After the poem is read (and volunteers are applauded) lead a discussion about scientific observations and their accuracy, using the questions below. The complete poem is on the following page.



It was six men of Indostan
To learning much inclined.
Who went to see the Elephant
(Though all of them were blind),
That each by observation
Might satisfy his mind.

The First approached the Elephant,
And happening to fall
Against his broad and sturdy side,
At once began to bawl:
"God bless me! but the Elephant
Is very like a wall!"

The Second feeling of the tusk,
Cried, "Ho! what have we here
So very round and smooth and sharp?
To me 'tis mighty clear
This wonder of an Elephant
Is very like a spear!

The Third approached the animal,
and happening to take
The squirming trunk within his hands
Thus boldly up and spake:
"I see," quoth he, "the Elephant
Is very like a snake!"
The Fourth reached out an eager hand,
And felt about the knee.
"What most this wondrous beast is like
Is mighty plain, "quoth he;
"Tis clear enough the Elephant
Is very like a tree!"

The Fifth who chanced to touch the ear,
Said: "E'n the blindest man
Can tell what this resembles most;
Deny the fact who can,
This marvel of an Elephant
Is very like a fan!"

The Sixth no sooner had begun
About the beast to grope,
Than seizing on the swinging tail
That fell within his scope,
"I see, " quoth he, "the Elephant
Is very like a rope!"

And so these men of Indostan
Disputed loud and long,
Each in his own opinion
Exceeding stiff and strong
Though each was partly in the right,
And all were in the wrong

So, oft in theologic wars
The disputants, I ween,
Rail on in utter ignorance
Of what each other mean,
And prate about an elephant
Not one of them has seen?

John Godfrey Saxe

If scientific observations are to be accurate, they must be complete. What mistaken impressions have these six blind men formed about an elephant? How could they have formed a more complete understanding of the elephant? How might their mistaken impressions be like those of scientists before telescopes or microscopes were invented? What can we learn from this about how we can improve our understanding of the Earth today?

## Page 7

- If possible, display a large poster of the Earth in space, or a slide of Earth projected in a darkened room. Ask the students to describe how they feel when they see the Earth this way. You might spark discussion by asking the students to suggest that we live on "Spaceship Earth."
- Students who are especially taken with the idea of viewing Earth from space might read a biography written by an astronaut who describes what it is like to look on the Earth as a whole planet.
- Have the students brainstorm systems they are familiar with. Ask them to draw a diagram of a system of their choice. As they draw the diagram, they might consider how the parts are related, and what would happen if one of the parts were removed.
- Have students write their complete address ending with the Universe. Then, ask them to "dissect" the address line by line, asking: What is the system? What are the parts of this system and how are they related?

## Pages 8 through 10

- This activity involves making an aquatic ecosystem. Expect your students to keep their ecosystems going for at least a month. Although you will be going on to study other topics, allow for your students to report on their ecosystems from time to time. Help the students focus their reports on the idea of a system. What are the parts? How are the parts influencing each other? How does the system change over time?
- In the next chapter your students will learn about systems diagrams and feedback loops. Have them apply those concepts when they prepare their reports on this laboratory investigation.
- This lab activity involves an aquatic ecosystem, but you can have your students construct terrestrial ecosystems if you prefer. Linda Russ and LaToy Kennedy have developed a terrestrial ecosystem activity that is described in the Teacher's Guide for *Ecosystem Change*.
- Gary Courts has pointed out that a very good extension of this laboratory activity is the classic Snail and Elodea lab described in the *BSCS Green Laboratory Manual*, as well as other textbooks. In brief, it involves four simple ecosystem environments, each using a stoppered test tube filled with fresh water, a few drops of BTB indicator. In the four sealed tubes place: 1) a single snail, 2) elodea (water plants) 3) both a snail and elodea, and 4) just water. A set of the four test tubes can be placed in the light, and an identical set can be placed in the dark. The students make predictions about which organisms will survive longest and why, and then make observations daily for four or five days. The BTB indicator reveals the presence of carbon dioxide in the water, and helps the students interpret the results. Gary Court's adaptation of this activity is described in greater detail in the *Teacher's Guide for Ecosystem Change*. If you are planning to present that unit to your students, it is recommend that you

wait until then to have your students do this activity. If you do not plan to go on to the Ecosystem Change unit, and do not have time for this extension, it can be done as a demonstration conducted by the teacher while the students do their own aquatic investigations.

- Play the "Everything is connected to everything else" game. Ask the students to name any two different physical things on Earth, and try to find words that will connect the two objects. This can easily be done by leading the connections toward soil, water, or sunlight. Examples: leather shoe and a rock; leather - cowhide - cow - plant - soil - rock; fish and a house, fish - water - tree - wood - house.
- Although a diagram of the water cycle is very simple, it can be used as an introduction to the very important and complex system of biogeochemical cycles presented in other units of the GSS series. You can have your students start with a very simple version of the water cycle and then expand it. Looking at the students' diagrams will help you to recognize possible misconceptions.

# Chapter 2: A History of Forest Use in the Pacific Northwest

## Pages 12 through 20

- The rain forest example is placed here to illustrate the kinds of complex problems that global systems scientists actually work on. Although it is easier for students to grasp the fundamentals of systems by considering cars, flowers, and thermostats, the authors felt a real-world example was called for to maintain student interest. Since this is an introductory guide, however, it is best not to plunge into the subject matter too deeply at this point, and plan to take up the subject later in the *Ecosystems Change* or *Losing Biodiversity* units. On the other hand, if students are highly motivated, they can do independent research on rain forests or other ecosystems.
- These pages contain a history of the rain forest ecosystems in the Pacific Northwest that set a context for the Field Trip of Chapter 4 in which students meet current rain forest researchers. Be sure to have students stop and answer the questions at the bottom of page 13 before reading the rest of the chapter.
- When after students have read the *History of Forest Use in the Pacific Northwest (Chapter 2)*, have a discussion to share views and feelings about these events.

## Pages 21 through 23

- The *Tree Impact Study* consists of four activities: *Tree Biodiversity* in which students make observations of trees, their surroundings, and ecosystems, *Tree Math* in which students determine the dimensions of a tree, *Tree Social Studies* in which students research the history of a tree, and *Tree Creations* in which students portray trees in their choice of artistic media.

# Chapter 3: Case Study: The Headwaters Controversy

## Pages 24-25

- The Headwaters Controversy is a superb example of how science and society are married. At times the marriage is rocky. This chapter is excellent for collaboration with a political science, social studies, or environmental history course.

## Pages 26-27

- The investigation *Measuring Old Growth Forest Loss* can be approached either as a simple visual inspection, analysis, and discussion of the four time sequenced maps of old growth forests in the U.S., or in a technology element using the computer software *Forest Analysis*. Without software, students can do analysis by superimposing a grid over the maps and counting number of grid squares that have old growth forest in a particular region of interest. They will need to deal with squares that are only partially filled.

  To use the software, you need to decide what strategy is best for your class from the "Strategies for Computer Use" on page 3.

## Pages 28 through 35

- The letter-writing exercise on page 35 is intended to provoke thought and clarification of ideas for the purpose of expression. It is not intended as a call for action on a particular viewpoint. In a way, it is practice for students to become effectively involved in future issues they encounter. The exact viewpoint is not as important as the manner in which the student justifies their views, based on facts, good science, and sound reasoning.

Class discussion on this whole controversy can be quite stimulating. You may need to pose some triggering questions, such as

- ❖ Do you agree with the lumber company views that wood is a renewable resource and reduces our need for fossil fuels?
- ❖ Can old growth forests really be restored?
- ❖ Is Pacific Lumber Company and environmentally friendly company as they purport?
- ❖ Does preservation of old growth forests threaten jobs in the lumber industry?
- ❖ Was 7500 acres enough old growth forest to preserve?

We recommend that the teacher NOT take a stand on any of these issues, but encourage thoughtful discussion.

# Chapter 4: Field Trip to Wind River

## Pages 36 through 48

- You may want to have a class discussion about what it might be like to work on the Wind River Canopy Crane project.
- Underscore the concepts that
  - a system is a group of interacting parts that functions as a whole.
  - systems change on long and short time scales.
  - interactions within a system may not be obvious.
  - systems have boundaries.
  - systems are parts of larger systems, which are parts of still larger systems.
- A good activity for demonstrating that we use systems in our thinking all the time is to ask your students to close their eyes and think of a friend or someone they would like to have as a friend. They should picture that person and themselves in some familiar place, doing something together. Now let them set the mental scene in motion by having the image of themselves do something or ask something of the other person. What happens next? If the modeling of the relationship is correct, similar action in the real world will be just as the model predicts. If something unexpected happens, then there is something wrong with the model and a correction is necessary.
- You can point out to your students that in this exercise they have been engaged in systems thinking. They have (1) constructed a mental model of the real world and (2) run a simulation of that model according to their understanding of the relationships in play. Making mental models is the basis of all forethought. We start mental models running with questions like what if... or suppose I... The more realistic our models are the better we are able to make sense of the world.
- The first research study conclusively demonstrating that rain forests affect local weather patterns was conducted in the Amazon River Basin in 1983, and reported in the *New York Times* on July 5 of that year. The study showed that a rain forest returns 75% of the rain water to the atmosphere—ten times greater than the amount returned by bare soil, and twice as much as is returned by land replanted with food crops or grasses.

## Feedback in Systems

- A common characteristic of systems is *feedback*. A simple example is a thermostat to control temperature of a home or building. In the thermostat, a piece of metal bends as temperature changes. If it bends far enough as the temperature gets colder, the metal trigger a switch to turn on the furnace to heat the building. As the temperature increases, the metal bends in the opposite direction until it triggers the furnace to turn off. The piece of metal inside the thermostat is a "bimetallic strip" composed of two different metals which expand at different rates when the temperature changes. When one side of the strip expands faster than the other side, the strip bends. The feedback process of a thermostat is known as a *negative feedback* process, because the feedback (switching the furnace on or off) acts to halt or reverse a change that is happening.

- Students can investigate how their eyes respond to light with a mirror and a magnifying lens, as described in the *Snackbook*, published by The Exploratorium in San Francisco, California. The students should hold the lens on top of the mirror, and hold them both up close to one eye until they can see a clear image of their iris. When the light is turned on and off in the room, they will see how the iris responds to the changing light levels. A very interesting variation is to block most of the light from one eye. As the room light is turned off and on, students will see that the iris of the shadowed eye opens and closes in responses to changing light levels observed by the other eye. Invite them to discuss how this feedback might occur within the brain.
- The negative feedback process that controls our eating is a focus of current medical research. A front-page article in the *New York Times* on January 4, 1996 reports that the hypothalamus in the brain plays a key role. As people eat, various chemical substances are produced in the stomach and intestines, including leptin, which is released from fat cells. The new research has found receptor sites for leptin in the brain. It is supposed that when leptin binds to a receptor a signal is sent to the cell nucleus which turns on other genes which in turn secrete GLP-1, a substance found to stop animals from feeding.
- It is actually an oversimplification to say that positive feedback causes a system to "break down." What actually occurs is that the system achieves a new stable state. For example, after a thunder storm the atmospheric conditions again stabilize, but the temperature and humidity are different from before. The "runaway greenhouse effect" on Venus caused the planet to reach hundreds of degrees on the surface, but the average temperature of Venus is now stable at about 900°F.
- Discuss previous examples of cycles or feedback loops, asking the students to identify each as an example of positive or negative feedback. You might also want to ask students to think of other examples of both positive and negative feedback loops. Finding examples of feedback outside of school can be a creative homework assignment.

## Pages 48-49

- Have students think of systems in their own lives by answering the questions on page 48.

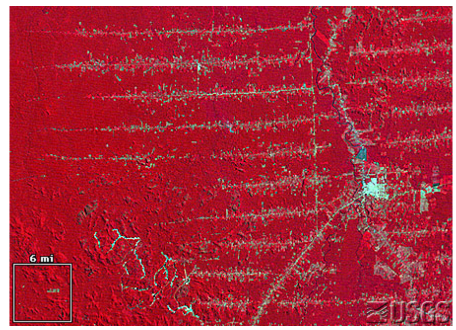
# Chapter 5: Losing Tropical Rainforests

## Pages 50-51

- There are natural and human-caused ways that forests can be altered or destroyed. Question 5.1 on page 51 is a good trigger for discussion of what processes might be at work in forests and lays the groundwork for the Investigation on the subsequent pages, which lead to analysis of satellite images showing deforestation of tropical rainforests from logging.

## Pages 52 through 58

### Investigation: Satellite Views of Rondonia, Brazil




- This investigation is intended to introduce students to the power of image processing software for analysis of satellite images of Earth in monitoring and assessing vegetation health, including forests. The software works on a variety of digital image formats and can be applied in many other investigations apart from this one. The latest software and additional investigations are available on the "Measuring Vegetation Health (MVH)" website at http://mvh.sr.unh.edu/.
- You should decide what strategy or combination of strategies is best for your purposes from those given in "Strategies for Computer Use" on page 3. The investigation can be done in environments ranging from only a single classroom computer with large screen display to a fully equipped computer lab with a computer for every student.
- The Investigation has four parts:
  - ❖ Introduction to ideas about vegetation and infrared light,
  - ❖ Introduction to identifying surface features in satellite images,
  - ❖ Introduction to the Vegetation Analysis software tools, and finally
  - ❖ Analysis of deforestation in Rondonia
- More than one session is needed. This is a very extensive investigation that is rich in technology applications, earth science concepts, biology and social studies implications. It requires at least three class sessions or a few nights of home investigation work by students to adequately accomplish the objectives of the investigation which are to learn how to use the Vegetation Analysis software to gain insights in a real world problem.

## Pages 59 through 63

- The interview with Dr. Nelson Dias, who is engaged in research in tropical rain forests, brings a very personal perspective to the investigation that the students have just done or are doing. He also can be an excellent role model for students to see how science is an exciting and vibrant field to enter.
- The summary of rainforest issues on page 63 is a good place to raise any current events or issues that may be happening. Don't forget to check the GSS "Staying Up To Date" web pages for more recent developments in rainforest deforestation issues:

www.lawrencehallofscience.org/gss/uptodate/1nwv.html

This area is closely related to the Climate Change GSS book which can be an excellent sequel to the module *A New World View*.

# Chapter 6: Towards a Sustainable World

## Page 64

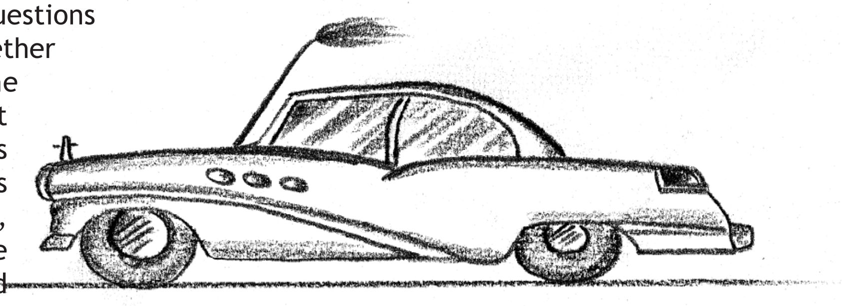
- The concept of a sustainable world is value-laden. As with other central values in our culture, such as respect for law and order, honesty and integrity, it is probably not necessary to spend a lot of time justifying it as a value. On the other hand, some students may strongly agree or disagree with the idea of a sustainable world as a goal, in which case an open discussion would be lively and fruitful.
- Accepting sustainability as a value does not mean that a person is necessarily an "environmentalist" or an advocate for any particular environmental action. It simply means that any decisions which affect the environment should take into account the long term implications of the decision.

## Page 65

- Return to the ecosystem started earlier (pages 8–10) and answer questions in the context of questions that the Canopy Crane project researchers are involved with.

## Pages 66 through 68

- You might have the students work in small groups to discuss the questions on page 52 before pulling together a large group discussion. The questions are designed so that the students will first discuss the concrete example (Carol's Grand Cooperative Car Program), followed by the historical example (Tragedy of the Commons), and then the much larger and more abstract idea of the entire Earth as a "commons."



- Ask the students if they can think of any other "commons" problems. For example, care of library and school books, sharing of sports equipment at school, and sharing of tapes or CD's among friends are all situations in which people share limited resources. Ask students to discuss both positive and negative experiences with such situations and to try and identify what led to satisfying experiences and what kinds of problems cropped up.

## Pages 69–70

- These pages are designed to help the students relate the ideas presented in *A New World View* to what is happening in the world today, and to their own values and actions.
- The activity suggested on page 69 is open-ended ("..find an article about an environmental issue that interests you...") This is because we expected that students would think more deeply about a topic that they selected than one that was assigned to them. However, you may want to change the assignment so that all of the students write about the same topic, or add other specific requirements to the assignment.
- You might consider the students' essays as an especially valuable form of data for evaluating the course. To what extent do the essays show interest in environmental issues? To what degree have students been able to use a systems approach to thinking about these issues? To what degree do they connect their own actions with prospects for a sustainable world?
- A concept map is one way for students to review what they have learned. It is especially helpful for visual learners. Students will remember the material far better if they construct the concept maps themselves than if you construct it for them. It will also reveal what they considered to be most important.
- Some teachers do not like the hierarchical structure of concept maps and prefer instead to create a "mind map," or "web" of ideas starting with a key idea in the center of the page and branching outward.
- Review can be made interactive and fun if students work in teams of three or four to construct concept maps in small groups. Give each team a block of Post-Its™ and a large sheet of butcher paper. Invite teams to make a maps of different chapters. Then allow time for the teams to share their ideas. It will be interesting to compare how different teams completed the same task.

## After Completing *A New World View*

- Hand out copies of the same three assessment tasks presented at the beginning of the course (on pages 8-9 of this Teacher's Guide.) You might want to use a different color of paper so the pre-and post-task forms are not mixed up. Ask the students to answer the questions to the best of their abilities. (You may or may not want to grade these.) Compare pre- and post-task papers for each student. Look for general trends in how students' ideas, information, and attitudes have changed. Use this information when planning and presenting the next unit in the course, or when teaching the unit again the following year.

# *Resources for Teaching* A New World View

This listing contains resources that are relevant to teaching *A New World View*, or two or more of the other Student Guides in the GSS series.

## Software

**Earthquest,** from Earthquest Inc., 125 University Ave., Palo Alto, CA 94301, (415) 321-5838. This mini-encyclopedia covers more than 150 subjects, which are brought to life through dozens of interactive challenges, graphics, animations, samples of languages and music, 43 maps, and a variety of charts and tables.

**EnviroAccount**, from EnviroAccount Software, 605 Sunset Court, Davis, CA 95616, (800) 688-9006. A personal environmental impact accounting software that enables the user to keep an environmental record as the year progresses.

**SimEarth**, Maxis Corporation, Two Theatre Square, Orinda, CA 94563-3346, 510-254-9700. SimEarth is a computer simulation of the grand cycles which maintain a livable environment on Earth. The program tracks atmospheric gases, air and water temperatures, crustal movement, biomass and biodiversity, and many other indicators. It was released as a best selling game. Maxis now publishes a teachers manual to accompany it.

**The Environment**, from Tom Snyder Productions, 90 Sherman Street, Cambridge, MA 02140, (800) 342-0236. This program comes with twenty-eight student reference books that are packed with advisors' facts and opinions about hundreds of actual case studies of environmental issues. A simulation of a town, and you're the mayor.

## CD-ROM

**Down to Earth! Close-Ups of Nature**, from Wayzata Technology, (612) 447-7321. Nearly 1000 color and monochrome images for use in desktop publishing, education, etc. Categories include: Marine environment, environmental impact, landscapes and food.

**Geo Ref**, from SilverPlatter Information, Inc., One Newton Executive Park, Newton Lower Falls, MA 02162-1449. A computerized bibliographic data base containing information from the Bibliography and Index of Geology, Bibliography of North American Geology, Bibliography and Index of Geology Exclusive of North America, Bibliography of Theses in geology, and Geophysical Abstracts. There are more than 1.6 million records in the data base, from 1785 to present. Each record in the data base is a reference to a journal article, book, dissertation, conference proceeding, or map. The records contain information necessary to describe the item, such as author, title, and source publication. IBM/compatible with MS-DOS (or PC-DOS 3.1) CD-ROM reader, 640 RAM and hard disk.

**GeoMedia**, from InterNetwork, Inc., 411 Seventh St., Del Mar, CA 92014. Teaching Earth Science through new technology. Textual and visual information on water cycle, earthquakes and maps. Macintosh only.

**Gloria Imagery and Bathymetry**, from Books and Open-File Reports Section, US Geological Survey, Federal Center, Box 25425, Denver, CO 80225. GLORIA imagery and bathymetry from the US Exclusive Economic Zone (EEZ) off Washington, Oregon, and California. The GLORIA imagery extends from 40 to 49 degrees

North Latitude while the bathymetry extends from 30 to 49 degrees North Latitude. IBM/compatible with DOS CD-ROM reader.

**NOAA LINC**, from The Library Corporation, PO Box 40035, Washington, DC 20016, 800-229-0100. Contains the bibliographic records of 22 NOAA libraries and information centers. IBM/compatible only.

**The World Almanac and Book of Facts**, from Discovery Systems, (614)761-2000. Over 1 million up-to-date facts that cover such topics as science, technology, economics, noted personalities, consumer information, sports, and much more

**The USA Factbook,** from Wayzata Technology, 800-735-7321 or 612-447-7321. An electronic almanac of the fifty United States and its territories [sic]. Includes information about vital statistics, economies, transportation, geography, traditions, etc. Published annually. Macintosh only.

**Joint Earth Sciences** , from USGS Department of the Interior, 810 National Center, Reston, VA 22092. Major portions of the USA are surveyed using Side-Looking Airborne Radar (SLAR) between the years 1980-1988. IBM/compatible, Dos format only.

**1990 Census Data**, from CD-ROM Inc., 1667 Cole Blvd., Ste 400, Golden, CO 80401, 303-231-9373; FAX: 303-231-9581. The 1990 census data are provided in dBase III format, allowing you to use it with a number of third party software programs. In addition, the data are provided by ZIP Code, as well as by tract, place county, state, and the US. IBM/compatible only.

**Environmental Periodicals Bibliography 1972-Present**, from CD-ROM Inc., 1667 Cole Blvd., Ste 400, Golden, CO 80401, 303-231-9373; FAX: 303-231-9581. More than 400,000 citations make EPB, from the Environmental Studies Institute of International Academy, the world's most extensive collection of records focused on environmental issues and research. IBM only.

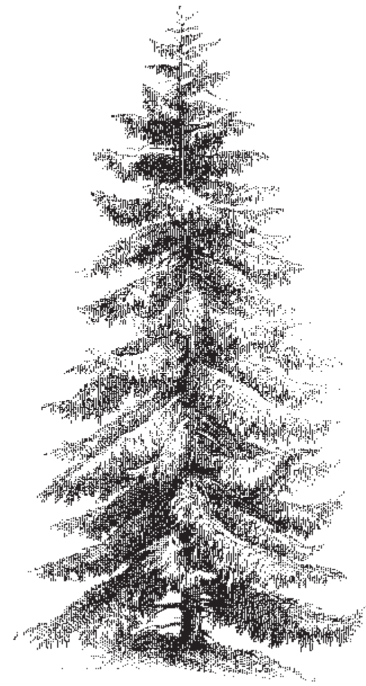
**Electronic Map Cabinet**, from CD-ROM Inc., 1667 Cole Blvd., Ste 400, Golden, CO 80401, 303-231-9373; FAX: 303-231-9581. Based on data from more than 300 distinct data bases from four Federal agencies. You can find the place you want to map visually (point and click) by latitude/longitude or by place name. Built-in graphics tools let you add text, lines, distances circles, and other graphic annotations to your base map in PICT format to your favorite graphics package for further enhancement. Macintosh only.

**Population Statistics**, from CD-ROM Inc., 1667 Cole Blvd., Ste 400, Golden, CO 80401, 303-231-9373; FAX: 303-231-9581. Full range of population and housing characteristics from the 1980 census for states, metro areas, counties, places of 10,000 or more, and other areas. Also Census Bureau population estimates by age, race, and sex for counties through 1984; population and per capita income estimates for 40,000+ areas for 1980 and 1986; and census population projections through 2010. SEARCHER search and retrieval software included with the disc searches the databases, creates and prints reports, generates files for use with other computer programs. IBM/compatible only.

**Natural Resource Metabase**, from National Information Services Corp. An integration of more than 45 different US government databases covering endangered species, resource development, wetlands, ecosystems, Pacific islands, etc. GSS: Biodiversity, Ecosystem Change

**Polar Pac**, from Western Library Network, 206-459-6518; FAX: 206-459-6341. A database of international polar regions. Holdings of 34 libraries in 15 countries are included. Over 85,000 bibliographic records an over 156,000 call numbers are provided. IBM/compatible only (386+).

**Life Sciences Collection**, from Cambridge Scientific Abstracts. Contains approximately 5,000 publications from journals, books, monographs, etc., that deal with biological, medical, and agricultural sciences. IBM/compatible only.



## Print Material

**Environmental Trends (by Council on Environmental Quality, 1989.)**, from U.S. Government Printing Office, Washington, DC. Excellent full color graphs of changes in recent decades. Specific to the US, so it has more "local" environmental information than other global sources.

**World Resources.** Copyright by World Resources Institute, Washington, D.C., published by Oxford University Press, New York. A report by the World Resources Institute in collaboration with the United Nations Environment Pragramme and United Nations Develpoment Programme. A thorough look at conditions and trends in the world environment, health, economies, population, climate, and so on. Neatly summarizes issues and problems and provides copious amounts of data. Updated every two years, each edition with analysis of trends in certain issues as well as data tables to support the text. The 1990-1991 version had special section on Climate Change. A teachers guide is available. Not all environmental issues in every edition.

**State of the World, 1995** (World Resources Institute), from World Resources Institute, Washington, DC. Annual summary of global trends in specific environmental issues. Some graphs, but mostly experts' analyses of a wide body of research on the topics. Probably the most widely quoted source of information on environmental trends.

**Environmental Data Report** (United Nations Environment Programme, 1989), from Blackwell, Inc., Cambridge, MA. Graphs and data tables by continent and country for numerous trends in pollution, resources, population, health, energy, waste, transportation, and natural disasters.

**Global Change Education Technology Fact Sheets**, School of Natural Resources, Ohio State University, 2021 Coffey Rd., Columbus, OH 43210, Attn: Dr. Rosanne W. Fortner, 614-292-2265; FAX: 614-292-7162. Produced jointly by the School of Natural Resources and the Department of Educational Studies at OSU. These sheets were used to find other resources in this guide.

## Magazines and Newsletters

**Earth Pulse,** 100 East Francis, Aspen, Colorado 81611-1424, (303)925-7376. K-12 Newsletter with educational articles and lab activities on global climate. Interdisciplinary activities based on current happenings.

**In Context, A Journal of Hope, Sustainability, and Change**, PO Box 11470, Bainbridge Island, WA 98110. This quarterly magazine is the best optimistic view of the future I've seen. It has many articles by leaders in science politics, futures studies, history, economics, psychology and history. Each issue has statistics that lend themselves to debate and encourages creative/alternative thinking. This is a journal you will not want to lose. I constantly use it in ALL my classes grades 9-12.

**PLESE Note...,** Ohio State Univ., College of Education and Natural Resources, 29 W. Woodruff Ave., Columbus, OH 43210, 614-292-7888. A newsletter for the Program for Leadership in Earth Systems Education, a project of Ohio State University's College of Education and Natural Resources. A newsletter for a group that is trying to increase the teaching of Earth Systems Science.

**The Greenhouse Gassette**, Climate Protection Institute, 5833 Balmoral Dr., Oakland, CA 94619. Newsletter which contains information and activities for high school teachers interested in teaching about global environmental change. Published and edited by former staff members of the GSS project, Richard Golden and Chris Harper.

**The Science Shift**, PO Box 185, Centerville, MD 21617-0185, (410) 479-3612. Mailed to 78 teachers in 23 states and 4 foreign countries, this newsletter lists of free materials for use in classes as well as review several current science books and some science fiction. Also contains information on which magazines are accepting student pictures-photos-essays. There is often a Word Search or some kind of Rainy Day Puzzle. Published by GSS Leader Robbie Robinette.

## Bibliographies

**Global Warming and the Greenhouse Effect,** United States Department of Agriculture, National Agricultural Library, Beltsville, MD 20705. Select bibliography put out by the Department of Agriculture.

**Climate and Global Change Education Resource Guide,** Office of Global Change, Graduate School of Oceanography, University of Rhode Island. Selected Annotated Bibliography put out by the University of Rhode Island.

# Books

**How to Build a Habitable Planet,** by Wallace Broecker, Eldigio Press, LDGO Box 2, Palisades, NY 10964. An excellent book on the physical evolution of the solar system and the Earth. Much about the chemical evolution of the Earth, including the carbon cycle. A few chapters on Earth's temperature controls, water systems, resources for civilization, and the future of the Earth at the hands of humans. Broecker, from Columbia University, is one of the premier so-called Earth System scientists. He is a chemical oceanographer who works a lot with biologists, geologists, and climatologists.

## Educational Programs and Sets of Activities

**Environmental Science Activities**, 1991 Alpha Publishing Company. This contains about 100 activities. "Food for thought" was the best in our opinion, but several others are useful.

**Global Change**, from the U.S. Geological Survey, Department of the Interior. Call (800) USA-MAPS. This packet contains a large poster with several activities and a short teacher's guide.

**Project LEARN**, from Project LEARN Office, NCAR, P.O. Box 3000, Boulder, CO 80307, (303) 497-8107 This program seeks to improve understanding of the atmospheric sciences and related mathematics and to improve science teaching methodology through experiential training.

**Science for Understanding Tomorrow's World: Global Change**, from the International Council of Scientific Unions, 51 Boulevard de Montmorency, 75016 Paris, France. This looseleaf guide for teachers contains activities for students in the age range 16-20 years old. Six units are included: The Changing Atmosphere; Clues from Our Past, The Global Carbon Cycle, Population and Land Use, Oceans, and Remote Sensing.

**Global Change Education Resource Guide**, by Lynn Mortensen, Editor, developed by the Office of Global Programs, National Oceanic and Atmospheric Administration (NOAA), 1100 Wayne Avenue, Suite 1225, Silver Spring, Mryland 20910. This resource notebook provides a wide variety of activities from several different sources. Activities are organized in six chapters: I. Natural Climate Variablility, II. Greenhouse Effect, III. Sea-Level Rise, IV. Ozone Depletion, V. Ecosystem Response, and VI. Decision-Making Under Scientific Uncertainty.

# *Bibliography for* A New World View

This listing contains references that were used in writing the Student Guide and Teacher's Guide for *A New World View*.


## Science Education Reform

*Benchmarks for Science Literacy,* American Association for the Advancement of Science, Project 2061, New York: Oxford University Press, 1993.

*National Science Education Standards*, National Research Council, Washington, DC: National Academy Press, 1996.

Rutherford, F. James and Ahlgren, Andrew, *Science for All Americans*, American Association for the Advancement of Science, Project 2061, New York: Oxford University Press, 1989, 1990.

*Scope, Sequence and Coordination of Secondary School Science, Volume 1: The Content Core*, a project of The National Science Teachers Association, 1992.

## Global Environmental Change

Brown, Lester R., *Building a Sustainable Society,* NY: W.W. Norton & Company, 1981.

Brown, Lester R., Flavin, Christopher, and Postel, Sandra, *Saving the Planet: How to Shape an Environmentally Sustainable Global Economy*, New York, London: W.W. Norton & Company, 1991.

Brown, Lester R., *State of the World, 1994: A Worldwatch Institute Report on Progress Toward a Sustainable Society*, (series) New York, London: W.W. Norton & Company, 1994.

Hardin, Garrett and Soden, Dennis L., *The Tragedy of the Commons: Twenty Years of Policy Literature, 1968-1988*, Montecello, IL: Vance Bibliographies, 1988.

Livi-Bacci, Massimo, A Concise History of World Population, translated by Carl Ipsen, Cambridge, MA and Oxford UK: Blackwell, 1989, 1992.

Meadows, Donella H., Meadows, Dennis, Randers, Jorgen, and Behrens, William W. III, The Limits to Growth, NY: The New American Library, 1972.

Meadows, Donella H., Meadows, Dennis, and Randers, Jorgen, Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future, Post Mills, VT: The Chelsea Green Publishing Company, 1992.

*Our Common Future*, World Commission on Environment and Development, New York, Oxford, UK: Oxford University Press, 1987.

Silver, Cheryl Simon, with DeFries, Ruth S., for the National Academy of Sciences, *One Earth, One Future: Our Changing Global Environment,* Washington, DC: National Academy Press, 1990.

Stern, Paul C., Young, Oran R., and Druckman, Daniel, Editors, *Global Environmental Change: Understanding the Human Dimensions*, Washington, D.C., National Academy Press, 1992.

Ward, Barbara, and Dubos, René, *Only One Earth: The Care and Maintenance of a Small Planet,* An Unofficial Report Commissioned by the Secretary General of the United Nations Conference on the Human Environment, NY: W.W. Norton & Company, 1972.

Wilson, E.O. Editor, *Biodiversity*, Washington DC, National Academy Press, 1988.

World Resources, 1994-1995: A Guide to the Global Environment, World Resources Institute in collaboration with The United Nations Environment Programme and The United Nations Development Programme, New York, Oxford: Oxford University Press, 1994.

## Earth Systems

Capra, Fritjof, *The Turning Point*, NY: Bantam Books, 1983.

*Earth System Science: Overview: A Program for Global Change,* Earth System Sciences Committee, NASA Advisory Council, National Aeronautics and Space Administration, Washington, D.C. 20546, 1986.

Jantsch, Erich, *The Self-Organizing Universe,* NY: Pergamon Press, 1980.

Laszlo, Ervin, *The Systems View of the World,* New York: George Braziller Inc., 1972.

Prigogine, Ilya and Stengers, Isabelle, *Order Out of Chaos,* NY, London: Bantam Books, 1984.

von Bertalanssy, Ludwig, *Problems of Life,* London: Watts & Company, 1952.

## Other Sources

### Examples of Feedback

Blakeslee, Sandra, "Signal to Stop Eating is Found: A Protein Tells Brain When Body Has Had Enough," *The York Times,* January 4, 1996, page 1.

*The Way Things Work, An Illustrated Encyclopedia of Technology*, NY: Simon and Shuster, 1967, pp. 20-21.

### Concept mapping

Novak, Joseph D., and Gowin, D. Bob, *Leaning How to Learn*, Cambridge, London, NY: Cambridge University Press, 1984.

### Water cycle in rain forests

Webster, Bayard, "Forest's Role in Weather Documented in Amazon," *New York Times*, July 5, 1983.

### Ecosystem activities

*Biological Science: An Ecological Approach (BSCS Green Version),* Boston: Houghton Mifflin Company, Fifth Edition, 1982.