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HANDS-ON ENVIRONMENTAL SCIENCE

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Jill M. Evers-Bowers

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ABSTRACT

HANDS-ON ENVIRONMENTAL SCIENCE

By

Jill M.Evers-Bowers

In order to provide students with an additional upperclass option in a limited science department, an environmental science class was added. It was designed to be an activity-oriented course that would increase students' awareness of environmental issues, promote environmentally accountable actions, and increase understanding of how science functions in the real world. By providing a variety of activities, students were able to gain laboratory and field experience. Students worked in groups to collect and analyze data, and drew conclusions based upon the data. Through these activities, students learned to use and apply the scientific process as they were introduced to many environmental issues, which equipped them with knowledge and experience to act in an environmentally responsible way.

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INTRODUCTION

At the small, rural high school where I teach, students are required to take two years of integrated science, which emphasize Earth science and biology. After that, there are only the "regular" advanced science courses for college bound students--chemistry, physics, and anatomy and physiology. As department chairperson and the science representative to the curriculum council, I decided that there was a need for another science class for the students who were not necessarily college-bound, and another science elective in general.

In addition, with all the seemingly new environmental issues, there was no place in the existing courses where these issues could be addressed. Previously, environmental topics were wedged in at the end of the first two years of other science courses. This practice rendered them to a lower status than other topics, and students dismissed them as unimportant. Because of many states not having any policy on teaching environmental education with the exception of voluntary infusion in grades K-12, the message sent is that environmental education is not as important or as rigorous as traditional science courses (Hausbeck et al. 1992).

My goal was to add a concept-oriented, hands-on, environmental science class to our curriculum. Students needed to learn that science, at its core, is not lecture and memorization of terms. They needed to get beyond textbook science, and into supplemental activities, including outdoor laboratories while invoking cooperative learning by doing experiments and activities in groups. In some cases, the activities lasted more than the traditional thirty minutes, and demanded more thought than one word answers to simple questions.

Furthermore, there was no place in the science curriculum where upperclassmen were required to write multiple, detailed laboratory reports, forcing them to analyze data, draw conclusions, and explain why "real life" situations did not work out as hypothesized. A large portion of student grades in this course was to be writing, as urged by the Michigan High School Proficiency Test, rather than the typical tests over scientific terms. This consideration gave an inter-disciplinary approach to the course, something Bybee (1991) stated as being necessary to effectively educate students about our planetary environmental crisis.

Some teachers say they are promoting cooperative learning by allowing students to work together on a worksheet. I believe students need to work toward a common goal, on a project or lab exercise for example, to benefit and learn from each other. Students do learn better, achieve more, and have superior cognitive reasoning strategies when there is cooperative interaction, compared with competitive and individualistic learning (Skon et al. 1981). Tobin et al. (1994) agree that there is value in truly learning to work together in science classes; they write:

> Although we do not view cooperative learning as a panacea, we consider it as a potentially valuable activity type because of the potential for students clarifying, defending, elaborating, evaluating, and arguing with one another. The negotiation and consensus building that are possible in cooperative groups suggest that teachers should give serious consideration to employing cooperative-learning strategies when they consider it appropriate.

Specifically, environmental conceptions can be developed using a knowledge-based approach through group learning (Ballantyne & Packer 1996).

Iozzi (1989a, 1989b) emphasizes that various types of teaching methods should be employed in a single course to effectively improve environmental values and attitudes, and this was my goal in developing and teaching this class. Hands-on activities, graphing exercises, observations, and experiments were emphasized along with role-play, journal writing, media, and standard lecture and discussions.

Collette and Chiappetta (1986) open a chapter of their text, *Science Instruction in the Middle and Secondary Schools* with the following:

> Laboratory work is a unique type of instruction that must be an integral part of science teaching. This type of activity involves students in firsthand experiences that permit them to participate in science as a way of thinking and as a way of investigating. Laboratory work provides students with concrete exemplars of science concepts and principles, which can serve to

reinforce course content.

Many feel that science teaching laboratories are places for learning (Lazarowitz & Tamir 1994). If one desires learning to take place, one must incorporate as much hands-on material as possible. In one study, student science achievement was considerably higher on standardized tests when students engaged in hands-on activities as little as once a week compared to those who experience hands-on instruction once a month or less (Stohr-Hunt 1996). There is further evidence to support activity-based programs. Those students who were subjected to new science curricula with activities compared to traditional, textbook style courses performed an average of 63% better in those classes (Shymansky et al. 1983).

In a study comparing hands-on and teacher demonstration laboratory methods, better scores resulted on procedural knowledge tests for those students who actually performed the experiments themselves (Glasson 1989). Procedural knowledge involves one's ability to apply reasoning skills to solve problems. Tobin (1990) found that students are able to construct scientific knowledge by solving problems in laboratories.

Certain skills can only be learned through laboratory activities, and such experiences may significantly enhance concept learning (Lazarowitz & Tamir 1994). Pickering (1996) also notes that students can become more enthusiastic when learning through laboratory methods. To capitalize on these theories and ideas, many laboratory exercises and activities were incorporated into my environmental science course.

As mentioned above, working, learning, and experimenting out of the classroom were also goals. "The conventional campus has become a place where indoor learning occurs as a preparation for indoor careers" (Orr 1990). To counter this, Orr encourages studying the students' world--the campus or school grounds--to broaden their visions of the natural world in which they live (Orr ibid). Many of today's biologists were inspired to pursue science careers because of field work they did earlier (Carter et al. 1990), and outdoor activities often circumvent the constraints imposed by limited supplies and budgets.

Our community school system owns acreage surrounding the high school, most of which is leased to area farmers, with the exception of a sizeable woodlot 0.2 miles behind the building. This provides a variety of small ecosystems to study or use experimentally, including fields with various crops, fence rows, the yard, and the forest. These natural areas "communicate clear educational opportunities and resource needs" (Simmons 1993). According to Tredway (1982), sites within a fifteen minute walk are ideal, as they are then available to students on a continuing basis. Long-term opportunities for observation contribute significantly to a child's learning.

These nearby areas are exceptional laboratories where students can conduct good science, such as being able to calculate the carrying capacity for gray squirrels. Also, the natural areas "could be a paradigm for understanding larger and more distant ecosystems" (Glenn 1995). To avoid feelings of isolation from nature, people need to view themselves as an integral part of the ecosystem. Humans are not separate from the environment nor are they different from all other living things (Gigliotti 1990). Schaefer (1992) advocates:

> making greater use (especially in education) of nearby farms, woodlands, and shores to reinforce a sense of connection with adjacent natural areas. The global focus usually draws attention to the biosphere as a whole and makes the local ecosystem seem almost insignificant and less valuable.

By using a local area, student interest in environmental issues should be heightened. Local context is concrete and relevant, compared with text information about global situations. About his own students who were exposed to field experience O'Neal (1995) writes:

> Very few of these students will become scientists, and even fewer will become ecologists, but they will become citizens faced with environmental choices. If we expect a society to have an interest in the global environmental crises, we must first motivate them with an experience in their own environment.

Holistic approaches to environmental education, including even as little as a one-day field experience, have been successful in affecting positive change in environmental orientations (Gross & Pizzini 1979). Firsthand experiences, including seeing, smelling, hearing, and touching the environment, have no substitute. O'Neal's research indicates that students enjoyed these excursions, coming away interested and more observant. Furthermore, there may have been long-term influences on their attitudes toward their environment (O'Neal 1995). Not only are environmental values and beliefs modifiable through these experiences, but ecological field-based instruction is effective in promoting understanding and retention of concepts (Lisowski & Disinger 1991; Iozzi 1989a; Iozzi 1989b).

Many students are unaware of some key ecological issues on both a global and local scale. In western Michigan, many fruit farmers spray their crops with innumerable chemicals, hunting is an economically important and popular recreation, and urbanization is starting to overtake us. Students need to be conscious of and able to evaluate these issues so they can make informed decisions as adults.

Globally, students have heard of rainforest destruction, problems of feeding the world, and out of control human population growth, but do they really understand the implications for themselves or their world? Gambro and Switzky (1996) conducted a national survey that revealed low levels of environmental knowledge among American high school students. These students had difficulty applying the basic facts to theoretical situations; some students had unsupported opinions. The findings of Hausbeck and colleagues (1992) agree but they also report that students desire further environmental education.

Young people today are aware of and concerned about environmental problems. According to Gigliotti (1990), "we seem to have produced a citizenry that is emotionally charged but woefully lacking in basic ecological knowledge". It appears that environmental education has failed to meet its traditionally accepted goal:

> Environmental education is aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution (Stapp et al. 1969).

It appears that for active participation in environmental issues to take place, both knowledge and affective behavior are necessary (Zimmerman 1996). According to Hungerford and Volk (1990), one must begin by providing students with basic ecological knowledge and then concepts. Iozzi (1989a, 1989b) urges using a spectrum of teaching techniques for improving environmental attitudes and values, particularly stressing direct involvement of the students with real-life environmental problems. A holistic approach is needed, one that deals with both the cognitive and affective domains. This combination is what is necessary to produce individuals who take environmentally responsible action (Zimmerman 1996).

Americans are environmentally aware; teachers need to exploit this awareness and use it as a motivating tool (Gambro & Switzky 1996). We as educators must strive to convert student awareness into workable knowledge that will allow them to make environmentally sound decisions. Additionally, we must add to their existing knowledge base to help promote a healthy awareness of environmental issues. By doing these things, we have a good chance of achieving the goal of producing citizens who are knowledgeable, aware, able to problem-solve, and motivated.

I asked my students to read some articles about local, environmental predicaments that are not found in traditional textbooks, and respond to them in the form of personal journals. This forced them to evaluate and justify their opinions, which are higher learning skills (Bloom 1956). This approach allows students to reflect on their own relationship with their environment and rationalize why certain issues are important (Ballantyne & Packer 1996). Through their writing and ensuing discussions, students develop their own values while learning content. Then they are better able to make informed decisions regarding current environmental concerns (Collette & Chiappetta 1986). This tactic not only incorporates more reading and writing, taking on an interdisciplinary approach, but involves subsequent learning about some local circumstances.

The media is a major contributor of environmental knowledge. Iozzi (1989B) makes the following recommendation:

> Employ television, video tapes, computers, films, audio tapes, and periodicals frequently in the classroom. Research has shown that media of all types constitute a powerful means for developing positive environmental attitudes and values in children. It has long been recognized that the more senses students can use, the better they learn. Media, which rely on both visual and auditory stimuli, such as television, are particularly powerful.

Classroom films have been shown to result in increased and retainable knowledge; in some groups attitude changes have occurred (Fortner 1985).

Because of their proven effectiveness, I felt many of the previously mentioned teaching techniques, were important enough to incorporate into the Environmental Science Class. These methods, such as journal writing, using a variety of hands-on laboratories and activities, and gaining field experience were used in designing the course. They too were used to evaluate student achievement and to determine the effectiveness of the class.

I wanted to make sure students understand the complexity of ecological and environmental enigmas. Each and every person does make a difference in the condition of our environment. All people need to become cognizant of how they affect the ecosystems and environment, not only where they live, but elsewhere. Interdependence is the key term, not independence. By being knowledgeable of the ways in which ecosystems are fragile and are affected by humans, yet can adjust and heal on their own, students should become more appreciative of their surroundings. This should transfer to stewardship of the entire world. Responsible citizens are usually the informed ones.

IMPLEMENTATION

Environmental Science was designed to be an activity-based semester course for high school juniors and seniors to expose students to real scientific processes. By having them participate in various lab activities, students moved away from the textbook and classroom enabling them to think critically, draw conclusions, and put their work into writing. This course was first taught in the spring of 1995, but the spring of 1996 was the "test" year where *Environmental Science* was further developed and evaluated.

Objectives of *Environmental Science*

-Identify and define basic environmental science terms

-Construct and analyze graphs

-Form hypotheses

-Demonstrate ability to use laboratory equipment

-Within laboratory groups, gather data

-Analyze data

-Write laboratory reports

-Draw conclusions from data

-Read *A New Leaf* and keep a journal based on readings

-State and justify opinions on environmental issues

Outline of Course

Unit one--4 weeks

Introduction--course expectations

Topics discussed

- biosphere, hydrosphere, atmosphere
- steps of scientific method
- ecology versus environment
- biotic versus abiotic
- biological magnification
- needs of organisms
- basic ecology/ecosystem terms
- biodiversity

Activities and Laboratories

- Construct stream discharge graph
- Observation skills activity
- Percent oxygen in air lab
- The Capture-Recapture Method activity
- Make and send Habitat Hunt clue boxes
- Determine location of received Habitat Hunt clue boxes
- Testing the Needs of Life lab
- Environmental Needs of Land Isopods lab

Reading, Writing, and Journals

- Practice writing lab reports
- *A New Leaf* (ANL)--Ch. 1: What are we doing to our water?
- ANL--Ch. 2: Can the lakes survive a spill?

Written test--over terms and concepts

Unit two--4-5 weeks

Topics discussed

- roles of living things, food webs
- trophic levels
- ecological pyramids
- chemical cycles
- habitats and niches
- exponential growth, limiting factors, carrying capacity
- ecosystem balance, predator and prey populations
- symbiosis
- succession

Activities and Laboratories

- Food web activity
- Different Rates of Decomposers lab
- NICHE computer simulation
- Habitats--The Choice is Yours: Planning map
- What Price is Open Space?: Role play
- How Human Activities Affect Deer Population graphing activity

Exponential Growth graphing activity
Individuals, Populations, and Homeostasis activity
Succession walk outside

Readings and Journals
ANL--Ch. 3: Protecting the water we have
"Introduction of Alien Species"--article
ANL--Ch. 4: Our environment is getting trashed

Media
Video--Last Feast of the Crocodiles
Video--What They Say About Hunting...
Video--The Un-endangered Species
Video--Sharks
Video--Keeping Nature in Balance
Video--Symbiosis

Written test--over terms and concepts

Unit three--3 weeks

Topics discussed
deserts
tundra
grasslands--savanna, prairie, steppe
forests--coniferous, deciduous, rain
Let-it-burn policy

Activities and Laboratories
Construct climatographs
Owl pellet lab

Readings and Journals
Oil in the Tundra Issues
ANL--Ch. 5: The hazards of incineration
Debate: spotted owl versus old-growth forests

Media
Video--Arctic: Life on the Edge
Video--Rainforest

Written test--over terms and concepts

Unit four--4 weeks

Topics discussed
freshwater biomes
marine biomes

Activities and Laboratories
Measuring Toxicity Levels of Chemicals using a Seed Germination Bioassay lab
Seeds: Food for Animals? lab
Estimating the Carrying Capacity for Gray Squirrels lab

Readings and Journals
ANL--Ch. 7: Agricultural chemicals may be out of hand
ANL--Ch. 8: Dangers at home
ANL--Ch. 9: Invisible dangers

Media
Video--Wild Things: An Earth Day Special

Written test--over terms and concepts

Unit five--2-3 weeks

Topics discussed

- abiotic factors of soil
- abiotic factors of water

Activities and Laboratories

- Soil Science Lab--Testing abiotic factors of soil
- Abiotic Factors of Water: Ball Creek--water testing lab
- Environmental Scavenger Hunt

Readings and Journals

- ANL--Ch. 10: Indoor Air
- ANL--Ch. 11: How does Michigan penalize polluters?

Written quiz--over terms and concepts

Background

In the spring of 1995, and again in the spring of 1996, *Environmental Science* was taught as an elective class at the high school. Juniors and seniors were allowed to take the course, after successfully completing freshman level applied science and sophomore level contemporary science. These are integrated science courses containing a mixture of life, physical, and Earth sciences. No other prerequisites were required, nor was a minimum science grade.

Environmental Science was a semester course, scheduled for the spring semester, second hour. Outdoor laboratory activities were scheduled mainly in the latter portion of the course chronologically as the weather became more cooperative. The second hour of the school day, although it is often still damp and cool outside, is a good time of the day for students to concentrate; attendance is good this hour too.

Materials

Addison-Wesley's 1995 edition of Environmental Science: Ecology and Human Impact, written by Bernstein, Winkler, and Zierdt-Warshaw, was chosen as the text for the course. I chose this text for the following reasons: the reading level is appropriate, it is attractive, and it is not too large a text to intimidate students nor to prohibit them from carrying it home! The book has an orderly approach that fits well with my objectives for the course, and each chapter contains activities that do not require elaborate equipment. Also provided in each chapter are feature essays that tie together environmental science and current events. The teacher's edition also has supplemental materials including an additional laboratory manual.

So that students could learn about the woes of our state's surroundings, I ordered A New Leaf: A Handbook for Preserving Michigan's Environment. This is not a regular textbook. It is inexpensive, yet is straightforward, informational, and easy to read. After reporting the many perils facing Michigan's resources, the handbook gives suggestions as to what can be done on a local level. A New Leaf also covers some of the environmental history of Michigan, enhancing the cross-curricular nature of the course.

When performing laboratory exercises and activities, students worked in groups. Students often set up their own groups, and the number of students per group depended on the availability of laboratory equipment. Usual group size ranged from two to four members. Each group member was responsible for assorted aspects of the given activity, varying from obtaining and setting up the necessary equipment, taking measurements, recording the data, and returning the laboratory materials to their appropriate places. Each group was responsible in making sure all of the obtained information was disseminated to its members.

Student Evaluation

Students were evaluated to determine a letter grade in a variety of ways, including written journal articles, laboratory reports, graphing exercises, tests, their ability to perform experiments and activities, and a few textbook assignments, with minimal worksheets or review questions from the book. These activities emphasized how science works in everyday life. More writing, based on both scientific and personal opinion, was required than in typical science classes so that students did not think that "complete sentence" writing only happens in English classes. These writing assignments could also be included in student portfolios needed for the Michigan Proficiency Test.

The written material was graded for neatness, proper grammar and sentence structure, and content. Students were evaluated on their ability to express their ideas clearly, concisely, yet include necessary details. Personal opinions and first person format were discouraged in lab reports.

Although a large part of the laboratory exercises involved students working cooperatively in groups, each person was responsible for his or her own write-up; in this way students had to work together, share data, discuss the results, and put them into their own words.

Learning to write quality lab reports was a major emphasis for the class. Initially, many labs that did not require extensive reports gave good practice writing reports. Students had to learn to be succinct, scientific, and objective. The results section had to contain only the facts, and any conclusions made were to be based on the data. Each section of the report was graded as follows: hypothesis--3 points, materials--2, procedure--3, results--3, analysis--4, conclusion--4, and overall neatness and effectiveness--1. A total of twenty points were possible for each lab report.

Students also had to write a journal entry for each chapter of A New Leaf, discussing their opinions and impressions of each topic. Discussions were not held prior to reading each chapter, so that my biases would not influence their opinions. This forced them to evaluate and justify, which are higher learning skills, while they learned about local situations. Each journal entry was worth up to five points. If their entry was too short, it was evident that their opinions were not based on the evidence given, or that they did not put much thought into it; subsequently, they did not receive the full five points.

Tests were written so that higher order learning skills were demanded of students. Test questions involved drawing conclusions from data, making inferences, and applying concepts to other similar situations. For example, one test question gave the flow rates for three various rivers; students were then asked to predict which river would have the highest levels of dissolved oxygen. All unit tests (Appendix C) varied in the number of points that could be earned, but reflected the amount of material presented.

Graphing exercises were added to teach students to manipulate and illustrate data and then to draw conclusions as some students have had difficulty setting up and constructing graphs. Some of the data sets graphed were human population levels and both rainfall and stream discharge over time. Graphs required included climatographs, those demonstrating exponential growth on log paper, and s-shaped ones showing carrying capacity. These were worth ten points.

Topically, in the first two units, the basic principles of ecology were taught, as found in the first six chapters of the Environmental Science text. Students from my school have scored low on the MEAP tests in the areas of energy flow through ecosystems, so they needed a solid foundation in this area. Human population growth and control also were incorporated into these two units. The topic of the third unit was biomes. The information on each biome was presented briefly since it is repetitious of geography classes. The teaching emphasis of each biome was on the environmental and ecological issues associated with each area. The focus of the fourth and fifth units was outdoor laboratories. The goal of these units was to introduce students to field work and reinforce some previously taught concepts.

When the class began, students were informed that they were a part of my master's thesis study. It was explained that their names were not to be used, and that their grades did not have to be used in my overall data. They were not at any personal or academic risk; they had the choice to permit me to use or disregard their scores in my analysis. Each student signed a consent form (Appendix A, I) allowing me to use the data in this work.

At the end of the semester, students were made aware that the surveys, evaluations and clinical interviews (Appendix A, II-IV) were voluntary. I told them to answer honestly and not worry about how answers might influence my opinion of them. While these tools were used to evaluate the course, they were not involved in the evaluation of the individual student.

Laboratory and Field Exercises

The laboratories and activities used in *Environmental Science* during this study were from a variety of sources. A few have been used straight from the students' textbook, while others were adapted from the text and assorted lab manuals to better fit our classroom needs. Many were new ones tested during my summer research, while some I designed myself at other times. These are listed below along with a brief description and the original source before I adapted them to *Environmental Science*.

1. Stream Discharge Graph -- Environmental Science (E.S.) text

Students traditionally have trouble graphing data. This introductory activity from the Environmental Science text allows students to work with supplied data. It forces students to make a hypothesis, construct and analyze the graph of the data, make a prediction based on data, and draw conclusions. Students are evaluated on the accuracy of the graph and the pertaining questions.

2. Observation Skills Activity -- J.M. Evers

Typically students go through life seeing clearly, but not observing. In reviewing the steps of the scientific method, the notion of observation needs to be reinforced, so I developed this activity. As a class, students go to the auditorium or gymnasium balcony. Here they get a certain amount of time to observe anything that is present. I allow them to take notes on what they observe. Upon our return to the classroom, they are to formulate questions to which they know the answers based on their observations. They then trade questions with a classmate to see if they really were observant. Answers are matched afterwards.

3. Percent of Oxygen in the Air Experiment (Appendix B, I) -- E.S. text

After brief discussions of the requirements for life and the layers of the biosphere, including the atmosphere, the Percent of Oxygen in the Air exercise fits in well. It is a basic exercise, introducing all of the major aspects of a complete experiment. It acclimates the students to our laboratory facilities and rules, as well as giving them a relatively easy experiment on which to write their first graded lab report.

4. Habitat Hunt Clue Boxes (Appendix B, II) -- J.M. Evers

Students learn about their own habitat and environment by developing clues that describe their surroundings. These are then assembled and sent to another school around the country. When clue boxes from other schools arrive, students have to use deductive reasoning to develop hypotheses as to where each box originated. Meanwhile students will have learned about other areas of the country in a fun manner. Students obtain credit for participating in assembling clues and varying amounts of credit based on their attempts to decipher the clues.

5. The Capture-Recapture Method Activity (Appendix B, III) -- E.S. text

Scientists often have to estimate the number of organisms in a certain population or area. This is especially important when trying to do density studies or show how one organism interacts with another. This activity portrays how estimates are made on a rare species of fish which is threatened by pollution by using the capture-recapture method. Accompanying questions and calculations are required of students.

6. Testing the Needs of Life Experiment (Appendix B, IV) -- E.S. text

There are certain needs which must be met in order for each organism to survive. This lab activity allows students to develop their own experiments with those needs using seed germination as an indicator of life. Students must develop their own controls, constants, and variables. I give suggestions, but they must come up with their own "experiments". Students must have their proposal approved prior to beginning, and then must turn in a written report at the conclusion of the experiment.

<u>7. Environmental Needs of Land Isopods Experiment</u> (Appendix B, V) -- E.S. text

I have found that the mere presence of living things in the classroom can be a motivating factor in science classes. Students do get excited (or scared) about interacting with strange little creatures. Most students are unaware of the existence of spikes, mousies, and wax worms, and know very little of their needs. It is a new realization that some organisms need or prefer very different conditions from humans. Grades are determined for this exercise through the required lab reports.

<u>8. Food Web Activity</u> (Appendix B, VI) -- Adapted from "All Tied Up" handout, with no authors noted

To illustrate the complexity and interactions in a food web in a simple yet fun manner, each student becomes a different organism in the web. By using a ball of yarn, they get actively involved by making connections between members. Students enjoy moving around and throwing things legally in the classroom!

9. Different Rates of Decomposers Experiment (Appendix B, VII) -- E.S. text

Often the role of the decomposer in the food web is neglected. Without decomposers, the Earth would be a heap of garbage and nutrient cycling would not occur. For once in their lives, students encourage rotting of some food samples. It shows that different decomposers grow at different rates on different types of food. Most have never before observed molds and bacteria with the naked eye or the microscope. Some rules of how to deal with microbes are also introduced. A standard lab report is required to evaluate each student.

10. Habitats--The Choice is Yours: Planning map (Appendix B, VIII) -- Environmental Science Activities Kit

In this activity, students must assume the role of a land-use planning team. Their task is to plan how to use a fictional area to support 10,000 people. All 10,000 people must live within the area. Students must make and defend their choices for how this ecosystem, which includes old growth pine forest, marsh, meadow, and oak woodland is developed into residential, industrial, commercial, and recreational areas. If students can justify their choices on their maps and have answered the accompanying questions correctly, they receive full credit.

11. How Human Activities Affect Deer Populations Graphing Activity (Appendix B, IX) -- E.S. text

This is another textbook graphing activity. It is designed to portray how humans activities affect a deer population over time. It uses data collected by the U.S. Forest Service of Arizona's Kaibab Plateau deer herd when they prohibited hunting, reduced predators, prevented overgrazing, and then allowed hunting again. Population numbers oscillate around the carrying capacity. Each student receives a grade based on his/her graph and whether or not he/she made appropriate inferences as required of the activities' conclusion.

12. Exponential Growth Graphing Activity (Appendix B, X) -- J.M. Evers

Starting with a human population of ten individuals, data is given for unlimited exponential growth over twenty-five years. This information is graphed on log paper, enabling students to make predictions of future population values. Also, after a certain period of time, limited birth control is enforced and graphed, displaying the differences in numbers over time. Students are evaluated as to whether or not their graphs are accurate enough to reliably predict future population sizes.

13. Individuals, Populations, and Homeostasis activity--Problems No. 3 & 4 (Appendix B, XI) -- Understanding Basic Ecological Concepts

This activity involves calculating population density of water lettuce in a picture using a quadrat and estimation techniques. This information is then used to calculate a water spider population which lives in the plants. The second part of the activity involves computing the classroom density of students at school. Factors which affect population density are discussed. Although some of the calculations are done as a class, individuals students are evaluated on their packet of questions and remaining estimations.

14. Nature walk/Succession talk -- J.M. Evers

As a class, we take our first walk to the woods in April after discussing succession. To illustrate secondary succession as best we can, we start with a plowed field, move to a weedy area followed by a plot of shrubs, and finish at the forest (not quite a climax). Many interesting plants and spring flowers are noted during the jaunt. Questions over succession and the areas which we examined are found on the written unit test.

15. Climatographs (Appendix B, XII) -- J.M. Evers

After discussing the characteristics of different biomes, including the basic climatic features, students generate climatographs. These are a great way to pictorially represent the rainfall and temperature over the course of a year for four very different biomes all on one graph. The climatographs are turned in for a grade based on accuracy and neatness.

16. Owl pellet study (Appendix B, XIII) -- Lab Aids Inc.

This lab exercise is a superb way to show the adaptations of some animals. We dissect the owl pellets after the discussions of the forest biomes, as well as the debate of the spotted owl versus the old-growth forests. Students can then estimate the diet of the owls and the prey populations needed to support these birds. The data sheets included in the lab kit are required of each pair of students working with one pellet.

<u>17. Measuring Toxicity Levels of Chemicals using a Seed Germination Bioassay Experiment</u> (Appendix B, XV) -- M. Hoekwater

By seeing whether or not seeds will germinate, students can determine the concentration of a particular substance that is lethal to living things. Students create serial dilutions using everyday type solutions such as salt or soap and place seeds on wicks within each container. Even "harmless" solutions can be toxic if the dosage is right. Thorough lab reports are due of each student at the conclusion of the experiment, and questions about the activity appear on the unit test.

<u>18. Seeds: Food for Animals? Experiment</u> (Appendix B, XIV) -- D. Akom, C. Hach, L. Vargo

In this field experiment students place sunflower seeds and peanuts at various distances from a large "parent" tree, and record the numbers missing over time at the different locations. This permits students to determine where seed-eating animals roam and why. Students are evaluated when they take the written unit test and when they generate a lab report.

<u>19. Estimating the Carrying Capacity for Gray Squirrels Experiment</u> (Appendix B, XVI) -- M. Hoekwater

Based on the numbers of oak trees of certain sizes, students predict the carrying capacity of gray squirrels in the woods behind the school. This exercise teaches sampling methods using quadrats and measuring skills. Again, students are asked to turn in lab reports and are questioned about the material on the next written unit test.

20. Soil Science Experiment--Testing Abiotic Factors of Soil (Appendix B, XVII) -- J.M. Evers

Many students are unaware of the properties of soil or differences among types of soil. Moisture; the content of the elements phosphorus, potassium, and nitrogen; and pH levels are determined on soils from three locations. These tests expose students to a whole new area of science and different types of laboratory and sampling skills. Students need to report their findings to the class and this material is tested on the following unit quiz.

21. Abiotic Factors of Water: Ball Creek--Water Testing Experiment (Appendix B, XVIII) -- J.M. Evers

This field experience gets the students away from school and right into the heart of their community--where Ball Creek passes under a road right in town. Here they use the Hach water test kits to put their knowledge of the abiotic factors of water into action. They know the area businesses and we discuss how these businesses might affect the water quality. There are questions on characteristics of Ball Creek's water on the unit quiz.

22. Environmental Scavenger Hunt (Appendix B, XIX) -- J.M. Evers

On the last activity day of the year, pairs of students search for natural items outdoors that start with certain letters of the alphabet. Retention of material from their previous field experiences is helpful as they race against other duos to find the most items during a set amount of time.

Audio-Visual Aids

Most students enjoy nature and animal films. A variety of videos were shown for an abundance of reasons. They were used to provide a break from the routine, as an alternative mode of teaching, to increase affectiveness and retention as TV is known to do, and for enjoyment. Each film is described briefly and given a value rating in Appendix C.

Simulation Activities

NICHE: Ecological Game Simulation is an interactive Macintosh computer program which uses a stimulating game format to explore the concept of an ecological niche. Our class swaps classrooms with a computer class and ten copies of the program are available. In *NICHE*, students must correctly place an organism in its proper niche by specifying the environment, range, and competitor for the organism. The organism may flourish in a well-specified niche or fail in a poorly specified one over time. Students are required during one class period to play and document five games, at least one of which is a successful game where their chosen organism lives through all of the rounds.

Role Play

Role play can be a powerful tool in developing opinions. As students assume the role of a fictional person in a debate type situation, opinions are constructed based on the information presented. A role play activity used in environmental science was "What Price Open Space?" (Appendix B, XX) which required students to take on the roles of participants at a zoning commission hearing. Roles included zoning commissioners, a developer, a banker, local land owners, and neighbors. Those who do not get active speaking parts are journalists who must write a report of what happened at the meeting or concerned citizens who write letters to the editor of the local newspaper.

Readings

The *Environmental Science* textbook contains many readings which are entitled "Enrichment Essays". Some discuss opposing viewpoints in controversial environmental problems, while others illustrate the ongoing nature of scientific research. They also explore the relationships between humans and their role in the world's ecosystems. Besides these text essays and *A New Leaf*, the supplemental reading, "Should Alien Species be Introduced to Ecosystems" is required. It is found in the Addison-Wesley *Issues/Case Studies* workbook. It discusses the disadvantages and benefits of both accidental invasions and planned introductions of alien species for increasing profits or recreation.

Field Trips

Due to limited funding, time restraints during a busy spring, and the unavailability of busing, field trips are minimal in our school system. However, students do get to walk to the woods behind the school and travel by bus three-fourths of a mile to Ball Creek to test its water. In the future, if conditions change, I would like to incorporate a trip to a landfill, wastewater treatment plant, and fast-food restaurant. I would ask students to keep all of their trash from lunch to calculate solid waste production for that meal.

RESULTS

Nothing similar to Environmental Science, the hands-on course, has been offered at our school before. Therefore, a comparison with old or other teaching styles is impossible. Because of the nature of the course and the target audience--those who may not really be interested in science--students usually indicate low or no knowledge of the topics to be discussed.

A condensed version of the comprehensive final exam was given as a pre-test (Appendix C, I) during the first week of class. The questions on the pre-test ranged from multiple choice questions about environmental terms to open ended questions asking what can be concluded from a list of data. The mean score on the pre-test was 50.1%. The post-test, which was identical to the pre-test except that it was given at the end of the course, revealed improvement in multiple areas. Not only did the mean score jump to 81.1%, but student knowledge of terminology and concepts increased. Also, the students' ability to determine the objective of a lab, write appropriate hypotheses, manipulate data, and draw legitimate conclusions escalated dramatically. Student answers to pre- and post-test questions confirmed this. This indicated that higher levels of learning, according to Bloom's (1956) taxonomy, have taken place. Rather than just being able to regurgitate terms, students are able to apply concepts and analyze material.

Personal interviews, written material, self-assessment, grades, and surveys appear to be other suitable indicators of student achievement. All of these were used in my evaluation of *Environmental Science*, and have been used to "fine-tune" the course.

Ten seniors and eight juniors enrolled in environmental science in the spring of 1996. Of these students, there were eleven girls and seven boys. Fourteen of these young people were college-bound, although the course did not require that.

The mean grade point average (GPA) based on a four point scale of those students coming into the class was 3.1, ranging from 2.2 to 4.0. Ten students achieved a grade in *Environmental Science* at or above their regular GPA. Of those remaining, three were within 0.2 or 0.3, while five did worse than their typical grade by 0.7 to 1.1 GPA units. The mean GPA of these students in science classes was 3.3 prior to figuring in the environmental science grades; after the class the mean GPA in all science classes dropped slightly to 3.2. For the majority of these students, science helps the students' overall GPA, but this class was more difficult than the typical science course. It is more difficult because it required self-discipline to keep on top of the activities and resultant reports; there were not many small reinforcement style assignments in the form of worksheets or text questions, and students had to develop the ability to use and apply learned concepts rather than just recite them.

The class average was 84%, which would convert to a straight "B" or a 3.0. These students appeared to earn grades typical for them. Through information gained by interviewing a representative sampling of the students, this was verified. Six students were interviewed, some of whom were juniors, seniors, male, female, academically high achievers, and lower achievers. Only one replied that he could have done better. Most appeared satisfied with their overall grade and the course. A few voiced dissatisfaction with some test and report grades. These students were among the lowest achievers in the class, often due to their lack of effort, to which they admitted.

Based on the clinical interviews (Appendix A, III) after the course, one-sixth noted that they did not care for experiments and activities. Another one-sixth said that only some exercises were enjoyable. Upon further investigation, it was discovered that these students found this format to be more work than if they just had to listen to lecture. A few students mentioned that although they enjoyed experiments and activities because they broke up the routine, they realized it took more effort. The concept orientation of the class was recognized as being more difficult; students found it harder to study for tests because it took more preparation than just memorization. They had to understand concepts and be able to analyze and apply them to other situations. These are higher order learning skills than just remembering basic knowledge or information.

All students polled said they enjoyed the *Environmental Science* course. Eighty-three percent gave the class above average ratings; no below average ratings were received. Everyone admitted that they now know more about some key ecological issues such as how humans impact the environment. All said they had learned enough so that it was a worthwhile class that they could recommend to others.

Two-thirds of the students interviewed acknowledged that they are now more interested in the environment. One-half implied that *Environmental Science* may or somewhat does influence how they live. One student excitedly told of how he was now going into outdoor recreation where he will continue some of his environmental education. Students are now more aware of, and some want to be involved with issues related to the environment. Many of the students put their interest into action as members of the school ecology club. They are now more equipped to live responsibly because of having a positive experience in environmental science.

Through journal writing, it appeared that students started to understand the importance of some local environmental issues. Their writing revealed that students are not apathetic, but actually are concerned and have a desire to improve their environment.

Although points were not given specifically for how well one worked within his or her group, students did have to cooperate to get their experiments and activities finished. At the beginning of the semester, some students were not comfortable working with others. By the end of the course, students appeared to work together well. I did not have to put people together or help form groups at the end of the semester as I did at the beginning, but students eagerly included one another. They seemed to have more clearly defined roles within the lab groups as time went on as well.

At the end of the semester students were given a survey (Appendix A, II) and asked to rank experiments and activities according to their enjoyment level and usefulness, using a scale of 0 to 4, with four being the highest. These number rankings were averaged for each activity and appear in Table 1. Based on the results, students appeared overall to enjoy and learn from the exercises, even though some students had mentioned that they did not care for activities during the clinical interviews. Even when some individuals scored some experiments or activities low, enough gave them high scores that the mean fell in the 3 or "pretty good" range. The overall mean of all activities averaged together was 3.09, confirming the previous statement that students liked the exercises and thought that they gained knowledge from doing them. Ironically, the same labs some liked the most, were given low scores by others. This shows me that there was a good mixture, catering to a variety of likes and dislikes, along with different learning preferences. Sometimes the ones

Table 1--Ratings of various activities--usefulness and how enjoyable

How students rated the value of various laboratories and activities at the completion of the course. The scale used is as follows: 1 = useless; 2 = minimal value; 3 = not bad, pretty good, learned something; and 4 = good, valuable learning experience. The mean rating of all activities is 3.09.

RATING	TOPIC
2.56	Individuals, Population, and Homeostasis Activity
2.72	Percent of O_2 in the Air
2.88	Soil Science Experiment
2.89	Estimating the Carrying Capacity for Gray Squirrels Experiment
2.89	Climatographs
2.94	Exponential Growth Graphing Activity
3.00	Environmental Needs of Land Isopods Experiment
3.06	Observation Skills Activity
3.06	Testing the Needs of Life Experiment
3.06	Seeds: Food for Animals? Experiment
3.11	Niche Simulation Activity
3.11	Habitats--The Choice is Yours: Planning Map
3.17	Food Web Activity
3.17	Different Rates of Decomposers Experiment
3.22	Measuring Toxicity Levels of Chemicals using a Seed Germination Bioassay Lab
3.22	Habitat Hunt Clue Boxes
3.24	Owl Pellet Study
3.35	Capture-Recapture Method Activity
3.56	Nature Walk/Succession Talk
3.63	Abiotic Factors of Water Experiment

who dislike something are the most vocal, so this was encouraging that most activities were appreciated overall.

Another form of evaluation used was a self-assessment survey (Appendix A, IV). At the beginning of the semester, students were asked to evaluate and rank their knowledge of a variety of topics that would be presented during the course. Students did not feel confident in most areas. The mean score or rating was 1.15, based on a zero to four point scale, indicating that they knew very little or just recognized the words associated with a topic.

The same list was given five months later and students were again asked to assess themselves. Results are shown in Table 2. As indicated, students have gained confidence in many areas. The new mean score was 2.65, a rating where they felt they could now talk about the topic. They also felt comfortable with the given topics and activities. The mean increase was 130%. This is consistent with the fact that pre- and post-test scores went up considerably, verifying that indeed students did learn the material. In addition to regular class work, this form of assessment assures me that students have not only gained knowledge, but they have gained confidence, too. The combination could be powerful in causing some positive action.

Table 2--Percent change of a variety of studied topics

The table shows how students rated their knowledge on a particular topic at the beginning and the end of the course. The scale used is from 0 = no prior knowledge, to 4 = a great deal of knowledge, very comfortable with the material. The mean score before the course was 1.15 while afterward it rose to 2.65. The mean increase is 130%.

BEFORE	TOPIC	AFTER	%CHANGE
1.70	Environmental Needs	2.82	66%
0.60	Rates of Different Decomposers	2.36	293%
1.40	Exponential Growth	3.00	114%
0.60	Abiotic Factors of Water	2.55	325%
0.70	Estimating Carrying Capacity	2.64	277%
1.10	Soil Sampling and Tests	2.91	165%
0.90	Succession	2.64	193%
1.50	Parts of a Lab Report	3.45	130%
0.60	Biological Magnification	2.64	340%
0.50	Biodiversity	2.82	464%
0.50	Ecological Pyramids	2.91	482%
1.00	Populations--Limiting Factors	3.00	200%
0.50	Symbiosis	2.18	336%
1.40	World Biomes	2.73	61%
1.30	Michigan's Environmental Laws	2.45	88%
1.40	Michigan Pollution	2.64	89%
1.70	Michigan's Water	2.55	50%
1.00	Valid Experiments	2.55	155%
0.90	Alien Species	2.82	213%
1.40	Equilibrium	2.64	89%
0.60	Owl Pellets	2.55	625%
0.70	Capture-Recapture Method	2.36	237%
1.00	Niches of Various Organisms	2.36	136%
0.30	Finding Toxicity Levels	2.55	750%

DISCUSSION AND CONCLUSIONS

The Course

Environmental science was taught twice thus far, in the spring of 1995 and 1996. Data used in this thesis is mainly from 1996, as 1995 was a developmental year. The spring is a hectic time at school with class trips, assemblies, athletic events, and early graduation. For these reasons and the fact that the weather is more cooperative in autumn, *Environmental Science* would be ideal to offer as a fall semester course. Regardless, we made the best of the available time in the spring. The outdoor labs near the end of the semester help maintain student enthusiasm and motivation. Ratings on the outdoor experiments and activities were higher (3.23) than the mean for all exercises (3.09), and students seem to enjoy coming to class to do field work.

From the spring of 1995 to the spring of 1996, certain videos were deleted and added from the syllabus and a few other things were changed around. (All videos shown in 1996 are listed in Appendix C.) More material was covered. Also, I was learning with the class as to how much time it took them to accomplish certain tasks and which things they did enjoy and understand.

In 1996, there was more direction and were more activities. Due to having taught the class once before, I was able to move faster and be more organized. I believe the course is much improved. This is positively reflected in the students' knowledge of and appreciation for the course and the environment. Overall student ratings of their enjoyment and perceived value of experiments and activities were higher in 1996 than in 1995. The mean of all activities was 2.91 in 1995 and 3.09 in 1996. Also, more students in 1996 were involved in the school's ecology club than in 1995. I plan to continue to improve the course as new or better material becomes available.

The overall goals of the course were attained. Students worked in laboratory groups to collect data, demonstrated their ability to use laboratory equipment, analyzed data, and made appropriate conclusions. They also kept a journal stating their opinions regarding environmental issues while they learned basic environmental science terms. Results of the activities evaluation and interviews were mainly positive. All of the interviewees thought the course was worthwhile and they would recommend it to others.

The Coursework--Laboratory Exercises, Activities

Overall, I believe the laboratory and field exercises and activities give my environmental science class a unique flavor; no other class at our school has near as many activities. As indicated by the activities survey or evaluation, students enjoyed each one for various reasons (See

Results section). Although a particular activity may have been low on one student's list, it was high on another's. Results of the survey are presented in Table 1.

Students indicated that one of their favorite activities was exercise involving dissecting *Owl Pellets*. Owl pellets are definitely peculiar, and students tend to severely like or dislike working with them. Students like the "see what you can find" aspect of the exercise, and they thought is was neat to be able to learn about owls' habits by looking at what they regurgitate!

The other particular favorite among students was *Testing the Abiotic Factors of Ball Creek*. This water testing experiment is a chance to get outside on a nice day and spend it by water. Of course students appreciate nature then! They realize that water testing is done by real scientists and the quality of their local water is important.

The *Nature Walk/Succession Talk* ranked high as well. This is the first time I take the students on our cross-country trail along the field and through our woods. They savor being outdoors for the entire class period and seeing some of what we have just discussed in class.

The least favorite activities as ranked by the students appear to be the *Population Density* activity and the *Percent of Oxygen in the Air* experiment. The *Population Density* activity is tedious and difficult. Students must count the number of water lettuce plants in a picture for their calculations. The mathematics is also difficult for some of the students to comprehend. Additionally, students do not get to move around, but are confined to working with some worksheets.

The *Percent of Oxygen in the Air* experiment was the first exercise of the year. Part of its purpose was to develop expertise in writing lab reports. Because it was the first report, I constructively criticized them so the students could improve them next time. Also, it was the first time many students had to repeat an experiment when something went wrong. For example, in some set-ups, too much water evaporated from the beaker allowing the water to drain out of the inverted test tube. Students thought they should be able to report on what they thought should happen rather than repeat the test to prove their hypothesis. Students' unfamiliarity with the scientific method and how to write lab reports inclined some of them to not appreciate this experiment.

Through the labs and activities, students gained immeasurable skills and experience, from soil sampling to setting up serial dilutions for the seed germination bioassay. Nevertheless in the future, I should incorporate more structured post-lab sessions to better facilitate student conclusions, especially at the beginning of the semester.

Journal writing offered insight into student thinking. After reading chapters about certain environmental concerns in Michigan, students had to respond. For example, after reading a chapter of <u>A New Leaf</u> entitled, "Dangers at Home" one student responded, "Most people are concerned about Michigan's hazardous waste problem, but don't think of how they are contributing to that problem through the use of fertilizers, bug sprays, and cleaning products." She went on with various facts and her opinions of how we could curb this problem.

Some students wrote more in-depth statements than I had imagined they would; a few were more impassioned than I would have guessed. A scant number of students were too brief in their comments or had difficulty expressing their feelings even though they were good students. The journals allowed students to articulate opinions about controversial topics yet they revealed whether or not the student had read and understood the main ideas communicated by A New Leaf.

At times students were reluctant to go outside if it was damp and chilly, but they were usually up for the challenge, at least to get a passing grade. Although I was able to coax every student to participate in every activity, "it may be a difficult task to get people to accept the need for personal lifestyle changes that may be necessary to solve some environmental problems" (Gigliotti 1990). Because of the extensive exposure of these students to a collection of activities, it is hoped that they will make the necessary changes.

The Students

There is a multiplicity of reasons why students take *Environmental Science*. Many take all of the science courses offered at my school. A few just need a class of any kind, or one that fits during that particular hour. Some want to have me as an instructor again; and some have friends in the class and want to be with them. This diversity of students can pose a problem. Not all are high achievers or want to work. However, the evidence of the journal articles, post-test scores, and lab reports indicates that all students end up learning and growing into more mature thinkers.

Environmental science is an everyday science. It continuously surrounds each and every person. Topics related to environmental science are often in the media, so this science seems to have more direct application to students' lives. Complaints such as, "How will I ever use this?" are not heard.

One concern of having *Environmental Science* in the spring is all of the school activities that interfere with regularly scheduled classes. Students have a high excitement and stress level toward the end of the semester. Seniors often have what they have self-diagnosed as "senioritis". Students do not care as much about their grades. Late or incomplete work becomes more frequent. When the seniors graduate a couple of weeks early leaving one-half of the class behind, the remaining juniors feel that they should not have to work anymore.

According to the clinical interviews, two-thirds of the students really enjoy the experiments and activities while another one-sixth likes them somewhat. However, the activities can also be a point of frustration at times. When laboratory exercises do not work, especially early in the semester, students want to write up the experiment the way they figure it was supposed to work out. I have to inform them that this is not the way science works. At that time, they grudgingly do the work again. It is not until the end of the course that they understand more clearly why this is necessary and is demanded by good science.

At various times during the course, students have two laboratory activities going at the same time. On a given day one activity may have to be checked on and observed, and another set up. This often inhibits some students who like to work on one task at a time and bring closure to it before beginning another. Also it requires more work--two reports. There are plenty of days of the *Environmental Science* course when students have time to work on activities, but do not have specific tasks to complete. It is a relaxed atmosphere where students are free to accomplish as much or as little as they choose during the hour. This is when some students do not handle the responsibility of a relaxed atmosphere very well. They have to choose how to use their time--whether or not they will be productive. Some excel while others realize that they need more structure to meet the deadlines. Late reports are not uncommon during these seemingly chaotic times. Both teacher and students are forced to be organized.

As previously mentioned, students work together in small groups during lab exercise and activities. Certain activities require groups of three while other are more suited to pairs. The groups of three are sometimes a regular lab pair plus an "outsider". It is difficult to have groups which function effectively where all are involved equally. However, over the course of the semester, groups seem to mesh better, as people discover with whom they can best work and interact.

Within the groups, students have to share or divide the responsibilities of setting up experiments, making observations, recording data, and distributing the final results to each other. Group members discuss their conclusions and debate their opinions of why certain events occurred in a given experiment. While one student does not always win over the other group members to his or her side of the argument, there is value in being exposed to the other viewpoints and having to defend one's opinions. Over the course of the semester, students seem to better understand the roles of being an effective group member and working toward a common goal. They learn to rely on each other, so as not to let each other down.

Students do enjoy the socialization allowed by an informal laboratory and activity style class. Lecture is minimal so students have more time to chat, especially within their small groups. It also allows me to interact more with the students--something I truly enjoy. A good bond forms between members of the class and myself.

The laboratory skills of students increased throughout the course. Based on lab reports, tests, and other observed lab skills, students became more aware of the steps of the scientific method and how science works in general. They learned how to draw valid conclusions based on their data, and put these into writing. From anecdotal evidence, I believe students became more mature, critical thinkers. This is great preparation for college or life. Hopefully this background will enhance their willingness to be involved as environmentally aware and active citizens. As Roa states, and I too believe, environmental education is a circular or triangular enterprise. The three sides to the triangle are informed, concerned and involved.

> Our students need to be informed. When informed they will probably become concerned. When concerned, they will want to become involved... The concern and involvement must be based on knowledge and understanding, but that knowledge does no good unless it results in concern and action (Roa 1993).

Data shows that students have gained knowledge in *Environmental Science*. Let us hope that the new knowledge of these students benefits our world.

LIST OF REFERENCES

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Ballantyne, R. R., & J. M. Packer. 1996. Teaching and learning in environmental education: Developing environmental conceptions. *Journal of Environmental Education* 27(2): 25-32.

Bernstein, Winkler, & Zierdt-Warshaw. 1995. *Environmental Science: Ecology and Human Impact*. New York, NY: Addison-Wesley.

Bloom, B. S. 1956. *Taxonomy of Educational Objectives. Handbook I. Cognitive Domain*. New York, NY: David McKay Co., Inc.

Bybee, Rodger W. 1991. Planet Earth in crisis: How should science educators respond? *The American Biology Teacher* 53(3): 146-153.

Carter, Jack L., Frank Heppner, Roy H. Saigo, Geraldine Twitty, & Dan Walker. 1990. The state of the biology major. *Bioscience* 40(9): 678-683.

Collette, Alfred T., & Eugene L. Chiappetta. 1994. *Science Instruction in the Middle and Secondary Schools*, p. 197. New York, NY: Macmillan Publishing Co.

Collette, Alfred T., & Eugene L. Chiappetta. 1986. *Science Instruction in the Middle and Secondary Schools*, p. 238. Columbus, OH: Charles E. Merrill Publishing Co.

Connecticut Valley Biological Supply Company, Inc. *Identification Guide*. Southampton, Massachusetts.

Fortner, Rosanne W. 1985. Relative effectiveness of classroom and documentary film presentations on marine mammals. *Journal of Research in Science Teaching* 21(2): 115-126.

Gambro, John S., & Harvey N. Switzky. 1996. A national survey of high school students' environmental knowledge. *Journal of Environmental Education* 27(3): 28-33.

Gigliotti, Larry M. 1990. Environmental education: What went wrong? What can be done? *Journal of Environmental Education* 22(1): 9-12.

Glasson, George E. 1989. The effects of hands-on and teacher demonstration laboratory methods on science achievement in relation to reasoning ability and prior knowledge. *Journal of Research in Science Teaching* 26(2): 121-131.

Glenn, David. 1995. Student field studies in forestry: A suggested paradigm for ecosystem research. *The American Biology Teacher* 57(4): 240-242.

Gross, Michael P., & Edward L. Pizzini. 1979. The effects of combined advance organizers and field experience on environmental orientations of elementary school children. *Journal of Research in Science Teaching* 16(4): 325-331.

Hausbeck, Kathryn Wald, Lester W. Milbrath, & Sean M. Enright. 1992. Environmental knowledge, awareness, and concern among 11th-grade students: New York State. *Journal of Environmental Education* 24(1): 27-34.

Hungerford, H. R., & T. L. Volk. 1990. Changing learner behavior through environmental education. *Journal of Environmental Education* 21(3): 8-21.

Iozzi, Louis A. 1989a. What research says to the educator. Part one: Environmental education and the affective domain. *Journal of Environmental Education* 20(3): 3-9.

Iozzi, Louis A. 1989b. What research says to the educator. Part two: Environmental education and the affective domain. *Journal of Environmental Education* 20(4): 6-13.

Lab-Aids Inc. 1979. *Lab-Aids #37 Owl Pellet Study--Student Worksheet and Guide.*

Lazarowitz, Reuven, & Pinchas Tamir. 1994. Research on using laboratory instruction in science. *Handbook of Research on Science Teaching and Learning*, edited by Dorothy L. Gabel, 94-99. New York, NY: Macmillan Publishing Co, a project of NSTA.

Lisowski, Marylin, & John F. Disinger. 1991. The effect of field-based instruction on student understandings of ecological concepts. *Journal of Environmental Education* 23(1): 19-23.

O'Neal, Lyman H. 1995. Using wetlands to teach ecology and environmental awareness in general biology. *The American Biology Teacher* 57(3): 135-139.

Orr, David W. 1990. The liberal arts, the campus, and the biosphere. *Harvard Educational Review* 60(2): 205-216.

Pickering, Miles. 1986. Laboratory education as a problem in organization. *Journal of College Science Teaching* 16: 187-189.

Ramsdell, Melissa. 1991. *A New Leaf: A Handbook for Preserving Michigan's Environment*, edited by Lisa J. Allen. Lansing, MI: Michigan United Conservation Clubs.

Roa, Michael L. 1993. About environmental education and this resource book. *Environmental Science Activities Kit*, p. vi, 33-41, 53-62. West Nyack, NY: The Center for Applied Research in Education.

Schaefer, Valentin H. 1992. Thinking locally in environmental education: The Victoria, B.C., experience. *Journal of Environmental Education* 24(1): 5-8.

Shymansky, James A., William C. Kyle, Jr., & Jennifer M. Alport. 1983. The effects of new science curricula on student performance. *Journal of Research in Science Teaching* 20(5): 387-404.

Simmons, Deborah. 1993. Facilitating teachers' use of natural areas: Perceptions of environmental education opportunities. *Journal of Environmental Education* 24(3): 8-16.

Skon, Linda, David W. Johnson, & Roger T. Johnson. 1981. Cooperative peer interaction versus individual competition and individualistic efforts: Effects on the acquisition of cognitive reasoning strategies. *Journal of Educational Psychology* 73(1): 83-92.

Stapp, W. B., et al. 1969. The concept of environmental education. *Journal of Environmental Education* 1(1): 30-31.

Stohr-Hunt, Patricia M. 1996. An analysis of frequency of hands-on experience and science achievement. *Journal of Research in Science Teaching* 33(1): 101-109.

Tobin, Kenneth. 1990. Research on science laboratory activities: In pursuit of better questions and answers to improve learning. *School Science and Mathematics* 90(5): 403-418.

Tobin, Kenneth, Deborah J. Tippins, & Alejandro Jose Gallard. 1994. Research on instructional strategies for teaching science. *Handbook of Research on Science Teaching and Learning*, edited by Dorothy L. Gabel, p. 81. New York, NY: Macmillan Publishing Co., a project of NSTA.

Tomera, Audrey N. 1989. *Understanding Basic Ecological Concepts*, revised by Joel Beller, 15-19. Portland, ME: J. Weston Walch.

Tredway, Dan. 1982. The local environment: A learning experience. *Science and Children* 20(1): 16-17.

Zimmerman, Laura K. 1996. Knowledge, affect, and the environment: 15 years of research (1979-1993). *Journal of Environmental Education* 27(3): 41-44.

APPENDICES

APPENDIX A: CONSENT FORMS AND SURVEYS

I - Copy of Letter of Consent
II - Activity Survey
III - Clinical Interview Questions
IV - Self Assessment Survey

APPENDIX A, I
Copy of Letter of Consent

Date: April 19, 1996

To: Student of Environmental Science
Dear Student:

I am presently working to complete my master's thesis at Michigan State University and I would like to use data collected from your class averages and surveys. Your name will not be used in my thesis, only the data collected from your scores. If you do not wish for me to use your work as part of my thesis, that is fine. There is no penalty in denying permission to use your data and you will not be at any personal or academic risk. However, for those who choose to participate, I appreciate it.

Sincerely,

Ms. Jill Evers

I give Ms. Evers permission to use data collected from my test scores as part of her master's thesis. I understand that Ms. Evers will maintain confidentiality with all student data.

____
your signature

I do not wish for Ms. Evers to use my test scores as part of her master's thesis. I understand there is no penalty for choosing to do so.

____
your signature

APPENDIX A, II
Activity Survey

ENVIRONMENTAL SCIENCE '96--Please take some time and fill out this survey seriously. Some of this information will be used in my master's thesis.

Please rank each activity from 1 to 4. Use this less than professional scale:

1 = a bummer, useless
2 = not that great, minimal value
3 = not bad, pretty decent, learned something
4 = good, valuable learning experience

____Percent of O_2 in the air--with steel wool

____Making observations--on the gym balcony

____Making Habitat Hunt clue boxes

____Capture-Recapture method of determining population size--toothpicks on driveway

____Environmental Needs of organisms--wax worms & spikes in boxes

____Environmental Needs of organisms--bean seeds in petri dishes

____Food web--with yarn & animal pictures

____Different decomposers at different rates on different foods--in petri dishes

____Niche simulation--computer program

____Exponential growth graph--on log paper

____Population density activity--water lettuce picture & worksheets

____Climatographs--circular graphs showing temperature & precipitation in each biome

____Community zoning commission meeting

____Habitat choices--planning map where you decided to put the town

____Owl pellets

____Nature walk/succession talk

* continued *

APPENDIX A, II

Survey--continued

____Finding the toxicity level of chemicals using seed germination experiment

____Estimating the carrying capacity of gray squirrels experiment

____Seed Predation experiment

____Soil sampling and tests

____Testing abiotic factors of water--Ball Creek

____Scavenger Hunt

____Anything else--please write it in

NOW please **go back through and <u>**circle**</u> the one you liked the most.

Hopefully, you have learned something you can take with you. Best wishes for an enjoyable summer and future! It's been fun for me--thanks,

JEvers

APPENDIX A, III
Clinical Interview Questions

Clinical Interviews--questions asked of students orally

1. Did you enjoy environmental science, the course? Why/why not?
2. Did you learn anything?
3. Are you more interested in the environment now?
4. Do you think you have a handle on how "real science" works? (At least a better handle than before you took this class?)
5. Are you more interested in science in general now?
6. Do you think a activity-oriented class is better than a traditional class?
7. Do you enjoy experiments and activities?
8. Do you learn better from experiments and activities?
9. Would you say you learned how humans impact the environment?
10. Are you more aware of some major ecological issues?
11. Are you now more concerned about some environmental issues?
12. Will/does it affect how you live?
13. How did this course compare to others, in terms of: a) enjoyment, b) the amount you learned, and c) the grade you earned?
14. Was it more concept oriented rather than just doing little worksheets and remembering terms? If so, did this make it more difficult?
15. Are there any career implications for you due to this class?
16. Do you have any other comments?
17. Would you say this class was worthwhile? Would you recommend it to others?

APPENDIX A, IV
Self Assessment Survey

ENV SCI--Please take some time and fill out this survey seriously. Right now, how much do you think you know about the following topics or activities? Use this less than professional scale to assess yourself. There is no penalty for how you rate yourself on each item. Some of this information may be used in my master's thesis. Thank you.

0 = I know nothing
1 = I know very little, recognize the topic
2 = I could talk about it with somebody
3 = I feel fairly confident with this subject
4 = Give me a college degree on it; I could teach it

_____Finding the toxicity level of chemicals using seed germination
_____Climatographs--circular graphs showing temp & precip in each biome
_____Niche simulation--deciding the various niches of different organisms
_____Drawing appropriate conclusions based on data

_____Environmental needs of organisms to stay alive
_____The different rates of different decomposers
_____Exponential growth--graphing
_____Population density--calculating & discussing
_____Testing abiotic factors--Ball Creek
_____Estimating the carrying capacity of an organism
_____Soil sampling and tests
_____Capture-recapture method of determining population size
_____Succession
_____Adaptations of organisms to their environment
_____Michigan's environmental laws
_____Michigan pollution
_____Ecology vs. environment
_____Biological magnification
_____Biodiversity

_____Limiting factors of a population
_____Owl pellets
_____Ecological pyramids
_____Control vs. constant
_____Alien species
_____Equilibrium
_____Symbiosis
_____Life on the tundra
_____The world biomes
_____Biosphere
_____Steps of the scientific method
_____Parts of a lab report
_____The water of Michigan
_____Dangers in your own home
_____Valid experiments

APPENDIX B: EXPERIMENTS AND ACTIVITIES

APPENDIX B, I
Percent of Oxygen in Air

Percent of Oxygen in Air

PROBLEM
What is the percentage of oxygen in the air?

MATERIALS

- -steel wool, small amount
- -test tube
- -ring stand
- -tape or wax pencil
- -clamp
- -metric ruler
- -beaker
- -forceps/spatula

HYPOTHESIS
After reading the entire lab, write a hypothesis that deals with how you can predict the percent of oxygen in a sample of air.

PROCEDURE
1. Fill a beaker so it is approximately one-half full of water.

2. Rip off a small piece of steel wool, approximately the size of the nail portion (but spherical) of your little finger. Pull the strands apart a bit and dip the whole piece in water.

3. Use the eraser end of a pencil to wedge the moistened steel wool into the bottom of a test tube. Do not compact the steel wool very much.

4. Invert the test tube. Use the clamp and ring stand to hold the test tube upside-down and lower it to a position just into the surface of the water. Put the test tube into the water enough (2-3 mm) so that the water will not evaporate overnight and lose contact with it.
Note: Because the test tube is full of air, no water will enter it.

5. Write your names on a piece of tape (or on the beaker with a wax pencil) and put it on your set-up. Place the whole set-up on the counter by the door.

APPENDIX B, I

6. Observe the set-up closely for several consecutive days. Record your observations. During this time, oxygen will be removed from the air in the test tube as it reacts with iron in the steel wool. As oxygen it used up, water will be drawn up the test tube. *Make sure the water level stays in contact with the test tube!*

7. After two or three days, use a metric ruler to measure how far the water has gone up into the test tube. Record this value to the nearest millimeter.

8. Measure and record the total length of the test tube to the nearest millimeter.

9. To determine the percentage of oxygen in the original air inside the test tube, divide the length measured in step 7 by the total length of the test tube measured in step 8. Multiply the quotient by 100.

10. Return all of your equipment to where it belongs. You may have to use forceps or a metal spatula to remove the steel wool from the test tube.

ANALYSIS

1. Did you notice any changes in the steel wool after two days? Explain.

2. Was oxygen removed from the test tube? Explain.

3. What are the possible sources of error in this method of determining the percentage of oxygen in air?

4. What would have happened if the test tube was not air tight with the surface of the water? Explain.

CONCLUSION

What is the percentage of oxygen in air? Show the calculations you performed to obtain your answer.

Adapted from Bernstein, Winkler, Zierdt-Warshaw. 1995. *Environmental Science*, p. 17. New York, NY: Addison Wesley.

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APPENDIX B, II
Habitat Hunt Clue Boxes

HABITAT HUNT--Making and Deciphering Clue Boxes

TEACHER'S EDITION

Written & performed by: Jill Evers, Kent City High School

Background: At the NSTA conference in St. Louis, November, 1994, several educators met at a session entitled Habitat Hunt. There were samples of clue boxes for us to examine. These were shoe boxes filled with various clues describing one's state or specific locale. These clues were anything from a pine cone of a characteristic tree, the state rock, a map showing glaciation, or a student devised poem describing a historical piece of data or famous people from the area. Addresses were then exchanged between those who wanted to send each other clue boxes to figure out each other's habitat.

Objectives: Students will learn about their own habitat and environment by developing clues to describe their surroundings. When clue boxes arrive from another school, students will learn about other areas in a fun manner.

Students will also have to use deductive reasoning to develop hypotheses as to where each received clue box originated.

Procedure:
Part One: Assign students into groups to work on various types of clues. These could be pictures cut out of magazines, data from local newspapers, or actual specimens. You need to determine how "science-oriented" all the clues should be. You could possibly allow each group to come up with three "science" clues and one "non-science" clue. Some student groups could be in charge of state species, climate, or vegetation, so as not to repeat other groups' clues.

All clues should then be numbered and placed in a box to be mailed. A key needs to be provided with an explanation of what each clue is or means. Additionally, students may want to provide a note or information about themselves. Finally be sure no addresses or state names show up by mistake on the back of some clue, but include on the key the exact location of the school.

APPENDIX B, II

Part Two: When a clue box arrives from another school remove the key and address label. Then pass around the clues one at a time and have students, either individually or in small groups, record what they think each clue is. Allow library or research time to identify the clues. After seeing all the clues, students should submit their guesses. Prizes, extra credit points, silly awards, or even grades can be given.

NOTE: Save each clue box that you receive; use them yearly. You may want to prearrange an "exchange time" with other schools, and send new boxes each year at that time.

APPENDIX B, II

HABITAT HUNT--Making Clue Boxes

Student Edition

Part One--CLUES

Objective: Make a Habitat Hunt Clue Box

You are to find or make "clues" that would allow students from other parts of the country to determine your habitat. These clues should allow the potential sleuths to figure out your location based on factors such as climate, local Earth science features, native organisms, local history, or other trademarks. Be original and creative. Each clue is to be numbered; you may have to tag certain items with a number. A key will be included, explaining each clue and providing the "answer", the school address. You may include a note about yourself or your habitat to go along with the key.

Part Two--DETECTIVE

Objective: Determine the location from which the Habitat Hunt Clue Box came.

When a Habitat Hunt Clue Box arrives from another school, number your paper for each clue provided. Record what each clue is and its potential significance, if not obvious. Use various references when necessary to further identify clues. Be as specific as possible. Based on the evidence, submit your deduction as to the origin of the clue box. Extra credit will be given to all correct hypotheses or the closest if no one figures it out.

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APPENDIX B, III
The Capture-Recapture Method Activity

The Capture-Recapture Method Activity

PROBLEM
Every year, a team of biologists estimates the population size of a rare species of trout that lives in Pavement Pond. Pavement Pond is polluted and fish numbers have dropped, but efforts are being made to clean it up. The biologists need to be able to check on the population size of the trout to see if they are recovering. The biologists use the capture-recapture method of estimation. They float on rafts and capture fish on baited hooks. The fish are marked, tallied, and thrown back into the water, hopefully unharmed. The biologists repeat the procedure a week later.

Imagine you are a biologist trying to answer this question: What is the size of the trout population in Pavement Pond.

MATERIALS (per class)
-one box of 500 toothpicks
-colored markers
-watch with second hand

HYPOTHESIS
The capture-recapture method will produce an accurate estimate of a population size.

PROCEDURE
1. A designated number of toothpicks have already been randomly placed in Pavement Pond. You will go with your class to the area of the driveway that represents Pavement Pond.

2. Toothpicks have been cut in half. Each half toothpick represents one trout. You will spend one minute capturing trout. Keep the trout you pick up in your hand, and return to class with them.

3. Using a marker, put a colored mark or dot on each captured toothpick. Count and record the number of toothpicks you captured. Everyone's total will be added together for a class count. Label the class total as the <u>marked trout in the total population</u>.

4. Give your marked trout back to Ms. Evers who will return the fish to Pavement Pond. They should again be scattered randomly.

5. Return to Pavement Pond. Again, spend one minute capturing as many trout as you can, and return to class with them.

APPENDIX B, III

6. Many of the captured toothpicks are probably already marked, indicating that they had been previously captured. Separate these from the unmarked toothpicks.

7. Tally and record the number of toothpicks recaptured by the entire class. Label these as the <u>marked trout recaptured</u>.

8. Count and record the **total** number of toothpicks, marked and unmarked, captured by the class during the second sampling. These are the <u>total trout captured</u>.

9. Multiply the number of <u>total trout captured</u> (step 8) by <u>marked trout in total population</u> (step 3). Divide this product by the <u>marked trout recaptured</u> (step 7). The result is an estimate of the trout population in Pavement Pond.

$$\frac{\text{Marked Trout Recaptured}}{\text{Total Trout Captured}} = \frac{\text{Marked Trout in Total Pop}}{X}$$

X = The size of the trout population in Pavement Pond

10. Return your toothpicks to the designated container.

11. Discuss the estimated population size with the actual number of trout in Pavement Pond.

ANALYSIS
1. To get an accurate estimate, why is it important that trout caught during the first sampling are returned to the lake unharmed?

2. In real life, what are possible sources of error with the capture-recapture method? How can these errors be minimized?

3. Could the capture-recapture method by used to accurately estimate the size of any population? Explain.

4. Is your estimate close to the actual value of fish in the pond? Were you surprised how close they were? What might account for the differences in the toothpick trout values based on our class' sampling technique?

CONCLUSION
What is your estimate of the trout population in Pavement Pond? Show the calculations performed to obtain your estimate.

Adapted from Bernstein, Winkler, Zierdt-Warshaw. 1995. *Environmental Science*, p. 29. New York, NY: Addison Wesley.

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APPENDIX B, IV
Testing the Needs of Life--Plants

TESTING THE NEEDS OF LIFE--Plants
What seeds need to germinate and survive

PROBLEM
What are some of the needs of plants to survive?

MATERIALS

-4 radish seeds	-2 petri dishes
-4 bean seeds	-wax pencil
-paper towel	-optional: uv light, Al foil refrigerator

HYPOTHESIS
Formulate your own hypotheses based on the variable you choose to test. Write two hypotheses and pick the best one.

PROCEDURE
Note: Steps one through three need to be done prior to day zero.

1. Decide what variable that affects seed germination you will test. Remember that you can only have one variable. Everything else must remain constant. Some variables you could use are light, temperature, water, salt, or fertilizer.

2. Check with Ms. Evers to get your plan approved.

3. Secure the necessary equipment for your set-up.

4. Label the bottom of one Petri dish "control" and the other one "experiment" with the wax pencil. Put your initials on both.

5. Fold a paper towel up so that it fits in the middle of the Petri dish. Moisten the paper towel. The top of the paper towel should be wet but not submerged. Repeat this for the other Petri dish.

6. Place 4 bean and 4 radish seeds on each paper towel. Wash your hands after handling the seeds as they often are coated with chemicals.

APPENDIX B, IV

7. Keep the two dishes close together at all times. Keep all conditions (except for your variable) the same for each dish. Set up your variable situation.

8. Observe the seeds over the next few days. Be sure the paper towels stay moist. Record the number of seeds that germinate from each set-up in a **data table**. Check the seeds closely to see if they split their seed coat.

ANALYSIS

1. Describe an observation of nature that might lead someone to develop an original hypothesis. (1 pt.)

2. What factors did you control in this experiment? (1 pt.)

3. What was the variable? Why is it important to have only one variable in an experiment? (1 pt.)

CONCLUSIONS

State your conclusions. Did you reject or accept your preferred hypothesis? Explain your reasons for accepting or rejecting your hypothesis on the basis of the data. If necessary, restate your hypothesis.

Adapted from: Bernstein, Winkler, & Zierdt-Warshaw. 1995. *Environmental Science*, p. 33. New York, NY: Addison-Wesley.

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APPENDIX B, V
Environmental Needs of Life--Animals

ENVIRONMENTAL NEEDS OF LIFE--Animals
Testing the preferences of land isopods

PROBLEM
What environmental conditions do land isopods need?

MATERIALS (per group)
- -paper towel
- -scissors
- -shoebox with lid or a box with a textbook for a cover
- -pipette
- -masking tape
- -3 waxworms*
- -3 spikes* (or mousies*)

*See a local bait shop

HYPOTHESIS
After reading the entire activity, write a hypothesis about the preferences of land isopods in part A. Write a second hypothesis for part B.

PROCEDURE
Part A deals with the preference of land isopods for light or darkness. Part B involves moisture versus dryness.

<u>Part A</u>
1. Place a strip of masking tape across the middle of a box (the shortest way across).
2. Cut the lid of the box across the width (the same way your tape goes), and cover one-half of the shoebox with one of the pieces. If you have a box without a lid, just cover one-half (even with the tape) with your textbook.
3. Place all 6 isopods--3 spikes and 3 waxworms--on the masking tape.
4. Leave the box undisturbed for 4-5 minutes. Make a data table to record the number of isopods that prefer *dark* or *light* conditions. 5. After 4-5 minutes, remove the half lid (or book). Quickly count the number of isopods on the dark half, on the masking tape, and on the light half. Record your results as *Trial 1.*
6. Gently slide the isopods back onto the masking tape, and repeat steps 3-5 two more times, recording the results as trials 2 and then 3.
7. Average and record the results of the three trials.

APPENDIX B, V

Part B

1. Line a shoebox with paper towel. Try to get it as smooth as possible. Place another strip of masking tape across the middle.

2. Moisten the paper towel on one side of the masking tape carefully with a pipette so that it does not run onto the other side.

3. Place the six isopods on the masking tape. Cover the entire box with the cut lid halves or textbooks (or lunch trays).

4. Leave the box undisturbed for 4-5 minutes. Make a data table to record the number of isopods that prefer *moist* or *dry* conditions.

5. After 4-5 minutes, remove the lids (or books). Quickly count the number of isopods on the wet half, on the masking tape, and on the dry half. Record your results as *Trial 1*.

6. Gently slide the isopods back onto the masking tape, and repeat steps 3-5 two more times, recording the results as trials 2 and 3.

7. Average and record the results of the three trials.

ANALYSIS

1. We used to do Part A with the paper towels lining the surface. However, some isopods would just crawl under the paper towel along the edges of the box. Explain how this could possibly lead to inaccurate results.

2. Pool your data to get the entire class results.

CONCLUSIONS

Were you able to accept or reject your hypotheses? Based on the class results, what can you infer about the environmental needs of land isopods? Describe their habitats.

Adapted from: Bernstein, Winkler, & Zierdt-Warshaw. 1995. *Environmental Science*, p. 42. New York, NY: Addison-Wesley.

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APPENDIX B, VI
Food Web Activity

FOOD WEB ACTIVITY

TO THE TEACHER: This exercise is designed to illustrate to students in a graphic, visual, "hands-on" way, the concept of a food web. It also shows the interdependence of species.

MATERIALS
-large ball of string or yarn
-signs with various pictures of plants and animals from various ecosystems. Each sign needs a string attached to it so students can wear them. Suggested representatives for a grassland-forest ecosystem would be grass, shrubs, tree (producers), insect, squirrel, rabbit, deer, mouse (first-order consumers) snake, hawk, wolf, mountain lion, eagle (second-order consumers), and a vulture (scavenger).

PROCEDURE
1. Pass out the signs randomly to students to put around their necks. Give the vulture card to the class clown.

2. Have the students stand in a circle around the room.

3. Hand the ball of yarn to one student; have him/her announce what organism he or she represents. While hanging onto the end of the yarn, he may then throw the ball to any other organism that would eat him **or** that he would eat. Continue throwing the ball while hanging onto the loose string.

4. Introduce or reinforce these terms as a food web is created: producers; first-, second-, and third-order consumers; herbivore; carnivore; omnivore; predator; and prey.

5. Make sure all students are incorporated into the web with the exception of the vulture.

6. Point out how all organisms are interconnected and what would happen if one person let go of his/her yarn.

7. Ask students what major group of organisms is missing from this food web. (scavengers)

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8. Suggest that a housing developer moves into the area and cuts down the trees and bushes and plows under the grass. Since these organisms have now died, they must let go of their strings.

9. Instruct the other members of the community that since their source of food is gone, they too must die and release their string.

10. Remind students that amid all of the death and destruction there is only one organism that is happy with all of this. That is the vulture who has been patiently observing the whole event. It is the scavenger who now gets to clean up the mess as you hand him/her the ball of yarn.

11. Collect the role cards as the vulture winds up the cord.

Adapted from: "All Tied Up", handout from a MSTA session, no author noted.

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APPENDIX B, VII
Different Rates of Different Decomposers on Different Types of Food

DIFFERENT RATES OF DIFFERENT DECOMPOSERS ON DIFFERENT TYPES OF FOOD (DIFFERENT CUBED = D3)

PROBLEM
Do different kinds of decomposers grow better on different types of food?

MATERIALS (per group)
-5 Petri dishes with lids
-paper towel or filter paper
-dissecting microscope
-wax pencil
-scissors
-pipette
-small amounts of five of the following foods: bread, cheese, dill pickle pieces, orange wedge, grapes cut in half, cracker, apple slice, or piece of lettuce

HYPOTHESIS
Write a hypothesis that pertains to the problem.

PROCEDURE
1. Mark the bottom of each Petri dish with your group name and number them 1 through 5.

2. Trace the bottom of the Petri dish on paper towel. Cut five circles of paper towel and fit them in the bottom of the dishes. (or put a circle of filter paper in each)

3. Moisten the paper towel (or filter paper) in the dishes, but pour off the excess water.

4. Lightly moisten the five pieces of food you are going to use.

5. Place one type of food in each dish. Record what type of food is in each numbered dish.

6. Put the covers **underneath** each dish in the back, side cabinet, which is a relatively cool, dark place. Expose the uncovered Petri dishes to the air for 24 hours.

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7. After 24 hours, using a pipette, add a few drops of water to each dish. Then cover the Petri dishes with the lids. You may now stack the dishes to save space.

Caution: *From this point on, do not remove the lids from the Petri dishes. Potentially harmful organisms may be inside.*

8. Observe the Petri dishes each class day for 1 to 2 weeks. Observe with your naked eye and with a dissecting microscope.

9. When the experiment is done, Ms. Evers will dispose of your Petri dishes. Do **not** just wash them out or throw them away.

ANALYSIS

1. How many different kinds of decomposers did you observe? What physical characteristics distinguished one kind of decomposer from another?

2. Did you find that one kind of decomposer can grow on different types of organic material? Describe your evidence.

3. What evidence did you find that organic material was being decomposed? How could you have proven this?

4. Based on your observations, what is the role of decomposers in the food web?

5. How would an ecosystem be different if no decomposers were present?

CONCLUSION

Did you find any evidence that different kinds of organisms grow better on one or another type of food? Explain. Did you accept or reject your hypothesis?

Adapted from: Bernstein, Winkler, Zierdt-Warshaw. 1995. *Environmental Science*, p. 71. New York, NY: Addison-Wesley.

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ACTIVITY 6: HABITATS—THE CHOICE IS YOURS

Activity Summary

In this activity, the students assume the roles of land-use planners. They are given a map of an undeveloped area where a new community will be built. As teams they decide how to use the land. Then they present their land-use plan to the class at a "Planning Commission Meeting."

Introduction

Every organism on Earth needs a place to live. A few organisms, like humans and rats, are able to live in a wide variety of habitats. Many organisms, though, have specific requirements for habitats. When their environments are changed, the very survival of many of these organisms is threatened. In fact, habitat destruction is the main threat to the world's wildlife.

Land-use decisions affect us all. The quality of our lives depends directly upon our surroundings. Whether we live in a pleasant neighborhood or an overcrowded unpleasant community depends, to a large degree, on planning decisions. Even if we live in huge apartment buildings, planning and cooperation among the tenants can make our surrounding environment less or more pleasant. Human habitats, including land dedicated to industry, transportation, governmental, and commercial uses, are built on what was formerly natural habitats.

It is easy to be so concerned about protecting the natural environment that we forget that we humans have needs and that by living on the Earth we change our environment. Those of us who are concerned about the environment need to keep in mind that others may have different priorities. Increasing human population, rising expectations, previously made decisions, and changing lifestyles all complicate the issue of land-use choices. In a way, the issue becomes one of quality (of life for humans and other organisms) versus quantity (of people, of "things," of income, of other organisms, of open space, of jobs, etc.). We must not forget, though, that it is very difficult, if not impossible, to undo damage done to a natural ecosystem.

When you introduce this activity, you should try to get the students to develop a feeling of "ownership" of their site so that they will want to develop it in the best (from their perspective) way possible. Don't make value judgments about their use choices. To some of them, it may be very important to have a lot of industry, especially if jobs are scarce in your community. To others, shopping malls, recreational sites, large lots for private residences, or natural sites may be of great importance. Let their planning groups work out the priorities and defend them before the class. Remind them, though, that the job of the planning commission is to make the best plan for everyone in the community, including future generations.

Requiring that the community meet all of its needs within the boundaries of Muir Valley helps make the point that the Earth itself is an ecosystem. What we do in our own communities has impacts elsewhere. In our real world, many of the impacts of our choices are not seen because they occur elsewhere. Examples include mining for minerals, logging, pesticide use, and disposal of sewage. One possible outcome of this activity is that the students might see the need to "think globally and act locally."

This activity works well if the students have already done the previous two activities in this book. It is also easy to tie it to the following activities dealing with timber, endangered animals, and endangered plants.

The color-coding system suggested corresponds fairly closely to the color coding used by most cities and counties. You should feel free to substitute other colors or patterns and to add, subtract, or, especially, subdivide categories.

Grouping

Groups of 4–6 students per planning team

Time

Introducing the activity: about 15 minutes

Student teams working on plans: 30–45 minutes

Presentation of plans to class: 3–10 minutes per team

Possibly another 30–50 minutes if you decide to have the plans revised

Anticipated Outcomes

The students will:

- increase their understanding of the interdependence of the organisms on Earth.
- increase their understandings of the complexity of land-use planning.
- increase their understanding of others' points of view.
- increase their ability to present information and to persuade others.

Materials

—Photocopied student pages:
- 6.1 Habitats—The Choice Is Yours: Background Information (one per student)
- 6.2 Habitats—The Choice Is Yours: Instructions sheet with map (one per student)
- 6.3 Habitats—The Choice Is Yours: Questions (one per student)

—transparency of Muir Valley Planning Map
—butcher paper or other large paper for enlarged student maps
—crayons or colored pens
—masking tape

Vocabulary

agricultural	buffer zone	closed system	commercial
density	endangered species	green belt	habitat
industrial	open space	public facilities	public lands
recreational	residential		

Teacher Preparation

1. Photocopy the Background Information sheet (6.1), Instructions sheet (6.2) and Questions sheet (6.3).
2. Obtain the other materials.
3. Some thought should be given to how to form the planning teams. Some options are:
   a. random selection
   b. let students choose teams
   c. assign teams
      (1) try to balance the teams academically
      (2) try to balance the teams with respect to organization and presentation skills
      (3) try to balance the teams according to apparent concern about the environment
      (4) set up teams so that one is mostly the "environmentalists," one is mostly those who will probably want only to build industries, one is neutral, etc.
4. Decide how the students are to code their maps. You might let each group decide on their own system. This would point out the value of having a standardized system. If you provide a code, the following system is suggested because it corresponds closely to the system used by cities and counties. You should indicate the code either on the student instructions (6.2) before duplicating them or make a large sign to hang at the front of the room.

single family housing:	yellow	*multiple family housing:*	orange
industry/manufacturing:	gray	*raw materials/mining:*	brown
agriculture (food):	dark green	*other crops:*	light green
commercial (stores):	red	*services (banks, doctors, etc.):*	pink
public buildings:	dark blue	*recreational uses:*	light blue
roads and parking lots:	black		

SAFETY CONSIDERATIONS

For reasons of liability, if you encourage the students to attend planning commission, E.I.R., or other hearings, be sure to either provide transportation as if it were a school field trip or be sure that it is understood that the trip is not required.

Procedure

1. Introduce and explain the lesson. Be sure to establish when the presentations are due. (If the students are working well, consider extending the planning time.) Be sure to emphasize that their presentation will determine the future of the area being developed and that the quality of their presentation may be as important as what they say. (*How* they say it may be as important to the outcome as *what* they say.)

APPENDIX B, VIII

2. Let the students use the transparency of Muir Valley to make large maps to use in their presentations. (Project the map onto butcher or other large paper held to the wall with masking tape.) Alternatively, you or a student assistant might make the large maps, or the transparency master can be used to duplicate enlarged maps on a copy machine.
3. At the appointed time, the student planning teams will present their proposals for the use of the land. This is a public "hearing."
4. After each presentation, allow a limited amount of time for questions to clarify their presentation. (This is not the time to debate the pros and cons. This is the time to understand the proposals.)
5. After the proposals have all been presented, allow for (polite) discussion of the relative merits of the various proposals.
6. After this, you may want to allow the student teams to revise their proposals, taking into account the input from the public hearing.

Discussion

1. Did different groups have different priorities for the land use?
2. Is there a simple "right" answer to such questions as land use?
3. Did your group neglect or omit any important types of use?
4. Did the various proposals take into account future generations?
5. Are some types of land use inappropriate for Muir Valley?
6. If all needs of the residents are to be met in the valley, which land use should have the most space allocated for it?
7. Are some uses of land incompatible with others?
8. How should land-use decisions be made? What should be the relative weight given to public input and the opinions of "experts?"
9. Discuss the phrase "Think globally, act locally."
10. Discuss the phrase "All things are interconnected."

References

Anonymous, *The Green Box*. Eureka, CA: Humboldt County Office of Education, 1989.

Clymire, Olga (principal writer), *California Class Project*, Costa Mesa, CA: Orange County Superintendent of Schools and the National Wildlife Federation, 1988.

Miller, G. Tyler, *Living in the Environment*. Belmont, CA: Wadsworth Publishing Co., 1990.

Roa, Michael L. 1993. *Environmental Science Activities Kit*, p.53-62. West Nyack, NY: The Center for Applied Research in Education

6.1 Habitats—The Choice Is Yours: Background Information

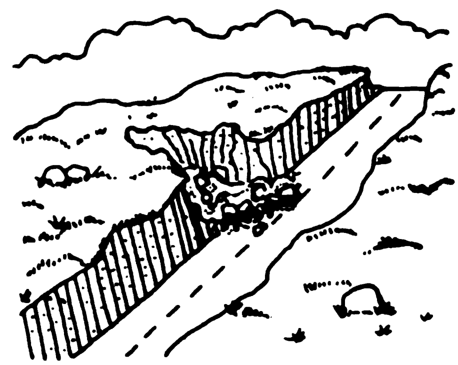
All organisms need space in which to live. Fish need water. Deer, birds, squirrels, and all other land animals, including humans, need land on which to build their "homes" and find or grow their food. There is a limited amount of land available for use by land animals. When people want to build houses, industries, roads, or recreational areas, land is needed. We use land to grow our crops. If undeveloped or natural land is used, communities of organisms are going to be disturbed, and perhaps destroyed.

In this activity, you are part of a land-use planning team. Your task is to plan how to use Muir Valley to support 10,000 people. (At the present time, the valley supports only one family that has a small farm.) At the conclusion of your planning time, you will present your proposal to the other students in the class. For the sake of activity, assume that all 10,000 people must live, work, shop, and have their recreational and other needs met in this valley, that is, that it is a "closed system."

In reality, most, if not all, communities depend on other areas for many things, such as electricity, raw materials for industry, certain foods, and so forth. What we do (or don't do) in one place has an impact on other places. Saving gas and oil helps protect otters and other wildlife. Wasting less wood helps protect forests and the wildlife that depends on forests. Saving energy reduces air pollution and acidic precipitation from coal- and oil-burning power plants. Avoiding the use of tropical hardwoods helps protect rain forests. Recycling aluminum protects areas where aluminum ore is mined. As John Muir said, "When we try to pick out anything by itself, we find it hitched to everything else in the universe."

Many species of plants and animals are either threatened with extinction or endangered. Many species have already become extinct. Many more become extinct every year. Some estimates are that as many as 10,000 species of animals may become extinct each year! Habitat destruction is the main cause of extinction. Hunting for commercial, subsistence, or sport purposes also creates problems for some species. Predator and pest control and pollution threaten others. Use of some species of animals as pets and plants for decoration destroys large numbers of animals and plants.

Aside from aesthetic and recreational reasons, there are many practical reasons why we should be concerned about other species. Many wild species hold great promise as sources of medicines, foods, and fibers. Ecosystems are very complex arrangements of plants and animals, and what affects one species may ultimately affect many others. Finally, there is the ethical question of whether mankind has the right to cause or hasten the extinction of other species. As you develop Muir Valley, keep in mind the many values of the plants and animals that live there.



APPENDIX B, VIII

Name ______________________ **Class** __________ **Date** __________

6.2 Habitats—The Choice Is Yours: Activity Instructions

Your planning team will be given (or will make) a map of an area. Your job is to plan a community in which 10,000 people will live, work, and shop, and will meet their recreational needs. When you have marked your plan on your map, you will present it to the rest of the class. You should be able to explain why you chose to use the land as you did.

The numbers below are not intended to represent actual land-use needs. The actual amount of land needed for a given use varies widely because of differing lifestyles, quality of land, and so forth. For the sake of the activity, use the space requirements given in the table below.

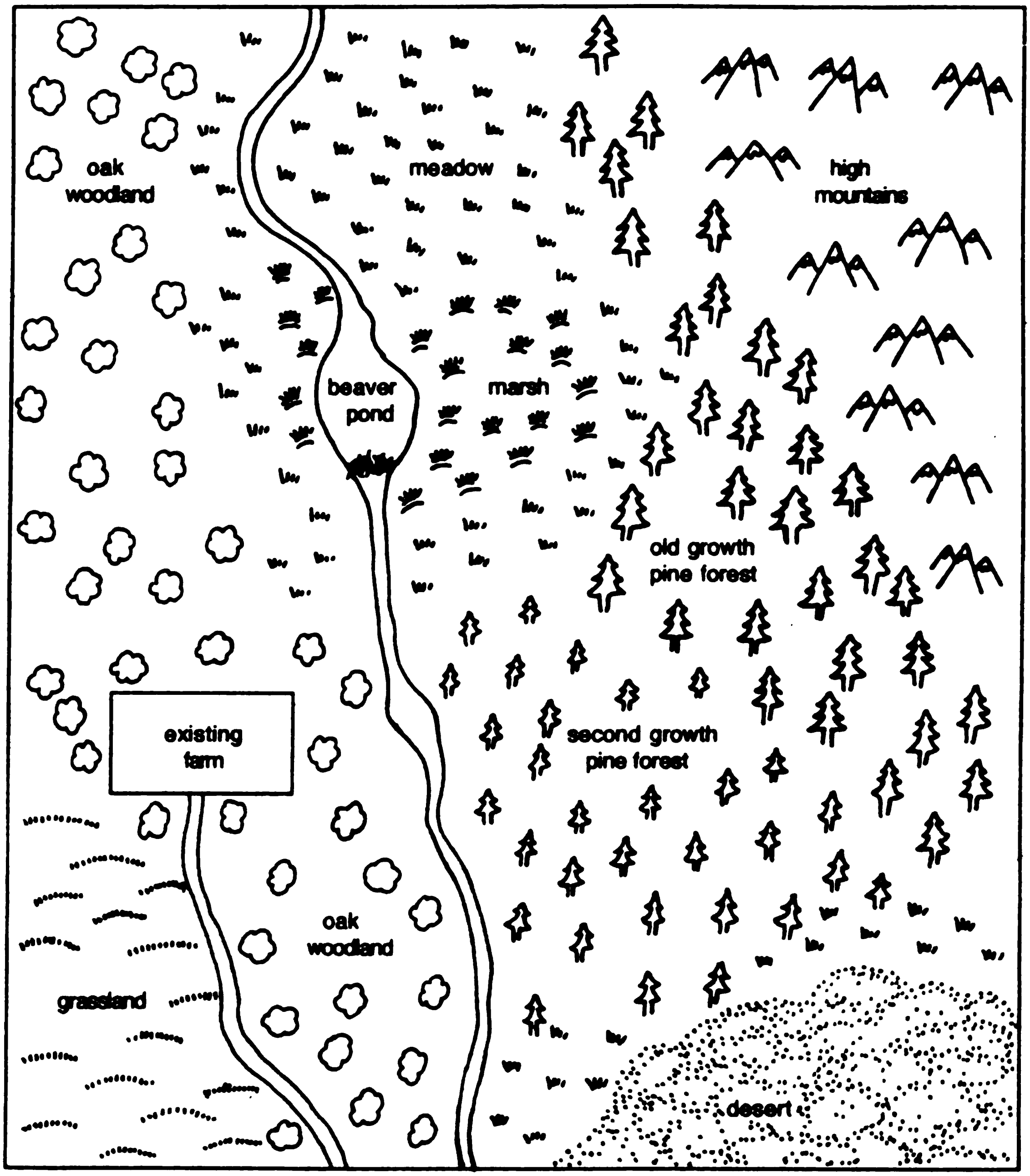
Note that you have several choices to make. For example, what proportion of the population will live in single-family residences as opposed to apartments? How much land will be allowed for such things as stores or roads? Will you allow more industry so that more money will come to Muir Valley?

Use the code provided by your teacher to indicate the various land uses.

USE	LAND NEEDED (acres)	COLOR/ SYMBOL
housing (single-family residences for 1,000)	80 acres/1,000	☐
housing (multiple-family residences for 1,000)	20 acres/1,000	☐
industry/manufacturing plants	1,200 acres	☐
raw materials/mining	6,000 acres	☐
agriculture (food plants, animals)	6,000 acres	☐
other crops (fibers, lumber, etc.)	3,200 acres	☐
commercial		
stores	80 acres	☐
services (doctors, banks, offices)	40 acres	☐
public uses such as schools, police, fire, water, public utilities, hospitals, waste disposal, government administration, post offices, etc—at least one of each. (labeled)	400 acres	☐
public recreational uses (developed areas for sports, parks, camping, etc.)	1,200 acres	☐
roads and parking	800 acres	☐

Name ______________________ Class ____________ Date ____________
(team or individual)

6.2 Habitats—The Choice Is Yours: Planning Map



1" = 1 mile

□ = 40 acres 1 mi^2 = 640 acres

APPENDIX B, VIII

Name ______________________ Class __________ Date __________

6.3 Habitats—The Choice Is Yours: Questions

1. How did your protection and use priorities differ from those of other groups? In what ways were they the same? How could such differences be resolved?

____

____

____

2. Should land be protected from development or other uses such as logging or oil drilling if an endangered species is found there? Under what conditions? Even if it is a species of plant or insect? Why or why not?

____

____

____

3. Should the government spend money to protect endangered species? Why or why not?

____

____

____

4. What is the relationship between human population and species endangerment?

____

____

5. What is the relationship between resource use and species endangerment?

____

____

6. Discuss the statement that "All things are interrelated."

____

____

____

7. Discuss the idea that we should "Think globally and act locally."

____

____

____

APPENDIX B, IX

How Human Activities Affect Deer Population Graphing Activity

ACTIVITY 5.2

PROBLEM

How can human activities affect a deer population over time?

MATERIALS

- graph paper

INFERENCE

Write an inference that relates to the problem.

PROCEDURE

1. In 1906, the U.S. Forest Service began protecting a herd of deer on a 300 000 hectare range on Arizona's Kaibab Plateau. In previous years, the Kaibab forest area had been overgrazed by cattle, sheep, and horses. Graph the Forest Service's data. Plot the year along the *x*-axis and the population size along the *y*-axis.
2. In 1906, the Forest Service estimated the carrying capacity of the range to be about 30,000 deer. Draw a straight horizontal line across your graph beginning at the 30,000-deer level. Label this line *Carrying capacity.*

ANALYSIS

What was the relationship of the deer herd to the carrying capacity of the range in 1915? 1920? 1924?

CONCLUSION

1. Describe the effects of the following actions taken by the Forest Service:
   a. 1907: Hunting of deer was banned. Also, the Forest Service began a 32-year campaign to exterminate natural predators of the deer. Thousands of predators were killed.
   b. 1920: Seeing that the range was deteriorating rapidly, the Forest Service reduced the number of livestock grazing permits.
   c. 1924: The deer population was on the brink of starvation.
   Deer hunting was allowed again. Deer shot by hunters in autumn represented about one-tenth the number that had been born the previous spring.
2. What do you think the Forest Service learned between 1905 and 1939?

Deer Population, 1905-1939

Year	Population	Year	Population
1905	4,000	1927	37,000
1910	9,000	1928	35,000
1915	25,000	1929	30,000
1920	65,000	1930	25,000
1924	100,000	1931	20,000
1925	60,000	1935	18,000
1926	40,000	1939	10,000

Bernstein, Winkler, & Zierdt-Warshaw. 1995. *Environmental Science: Ecology and Human Impact*, p. 87. New York, NY: Addison-Wesley.

APPENDIX B, X
Exponential Growth Graphing Activity

EXPONENTIAL GROWTH GRAPHING ACTIVITY

PROBLEM
Can we accurately predict future populations when they are growing exponentially?

MATERIALS
-ruler -graph paper -semi-log paper

PROCEDURE--A
1. The data presented begins with a human population of 10 persons. It is growing at a rate of 17%. Graph the values listed under UEG on regular graph paper. Put the years on the x-axis and the population numbers on the y-axis. Label this curve "UEG", which stands for unlimited exponential growth.

2. The second list of data represents a population that starts employing birth control after the population reaches 100 persons. This happens at year 15. Graph this column of data and label it "LBC", meaning limited birth control.

3. Find the population level at year 15 and draw a horizontal line across at that level until year 25. Label this "ZPG", for zero population growth.

DATA

	UEG	LBC
Original	population = 10	Original population = 10
Year 1	pop = 11.7	pop = 11.7
Year 2	pop = 13.7	pop = 13.7
Year 3	pop = 16.0	pop = 16.0
Year 4	pop = 18.7	pop = 18.7
Year 5	pop = 21.9	pop = 21.9
Year 6	pop = 25.7	pop = 25.7
Year 7	pop = 30.0	pop = 30.0
Year 8	pop = 35.1	pop = 35.1
Year 9	pop = 41.1	pop = 41.1
Year 10	pop = 48.1	pop = 48.1
Year 11	pop = 56.2	pop = 56.2
Year 12	pop = 65.8	pop = 65.8
Year 13	pop = 77.0	pop = 77.0
Year 14	pop = 90.1	pop = 90.1
Year 15	pop = 105.4	pop = 105.4
Year 16	pop = 123.3	pop = 113.8
Year 17	pop = 144.3	pop = 122.9

-continued below-

APPENDIX B, X

	UEG	LBC
Year 18	pop = 168.8	pop = 132.8
Year 19	pop = 197.5	pop = 143.4
Year 20	pop = 231.1	pop = 154.8
Year 21	pop = 270.3	pop = 167.2
Year 22	pop = 316.3	pop = 180.6
Year 23	pop = 370.1	pop = 195.1
Year 24	pop = 433.0	pop = 210.7
Year 25	pop = 506.6	pop = 227.5

ANALYSIS--A
1. Make a prediction of the UEG population level for year 29.
2. At year 35, predict the population of those using birth control.
3. Are these predictions (in questions #1 and 2) accurate?

PROCEDURE--B
1. Using the semi-log paper, label the x-axis "Year" and number 0 to 36 along the bottom.

2. Along the y-axis, write the label "Population" and start with 10 on the bottom line. Number by 10's. Each horizontal line represents one person until 60. Then each horizontal line represents two. When you reach 100, the next number you will have is 200. After 100 each line stands for ten persons, until 600 when each line depicts twenty. (Your graph should end up going from 10 to 1000 persons.)

3. Repeat steps #1-3 from procedure A.

ANALYSIS--B
1. Make a prediction of the UEG population level for year 29.
2. At year 35, predict the population of those using birth control.
3. How do these predictions compare with those from your first graph? Which are more accurate?
4. In your opinion, is ZPG a reasonable option? What would have to happen in order for it to be achieved?

CONCLUSIONS
What conclusions can you draw from these two types of graphs? Refer back to the problem stated at the beginning of the activity when writing your conclusions.

Adapted from: *Exponential Growth Lab*, handout from MSTA session, no author listed.

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JMEvers

INDIVIDUALS, POPULATIONS, AND HOMEOSTASIS

IF ECOLOGISTS or ecology students wanted to study the organisms in a certain area such as the pasture we observed, they would have two choices. They could study each cow, each grass plant, each specific shrub one by one. In that case, they would be studying individuals. It would be easy to do this if the subject were cows, but it would be most difficult to separate and study each individual grass plant.

The second choice would be to study all of the cows, all of the grass plants of each specific kind, all of a certain shrub type in the area at the time of study. To investigate a **population** of organisms—a group of the same kind of individuals in a given space at a given time—would be the ecologists' usual choice. The time element is important, for a population might differ at various times of the day, during the different seasons, or from year to year. Here are two examples of populations: the number of pigeons within Chicago's city limits in 1990 and the number of corn plants per acre in Mr. Doak's field in July.

On page 16 you see a photograph of an aquatic plant called water lettuce as it floats on the surface of a Florida swamp. How many individual plants can you identify? If you wanted to study these water lettuce plants as a population, how might you go about it?

Populations are usually measured in terms of density. Ecologists calculate density (D) by counting the number of individuals in the population (N) and dividing this number by the total units of space (S) the counted population occupies. The formula for calculating density thus becomes:

$$D = \frac{N}{S}$$

In studying population density on land, ecologists use the dimensions of length and width when measuring the occupied space. They therefore deal in square units. When studying aquatic environments, they use length, width, and depth. Space is then measured in cubic units.

Tomera, Audrey N. 1989. *Understanding Basic Ecological Concepts*, revised by Joel Beller, 15-19. Portland, ME: J. Weston Walch.

APPENDIX B, XI

Water lettuce on a Florida swamp. (Courtesy of H. R. Hungerford)

APPENDIX B, XI

DENSITY: *The number of individuals of a particular kind of organism per unit of space at a given time.*

Let's look at one example of density so we may apply the formula $D = \frac{N}{S}$. When ecologists study forest populations, they often use a space of a definite size. This space is called a **quadrat**. The size of a quadrat is usually 10 meters square (10 m by 10 m). Plots of 10 m² are marked off with twine. Within each quadrat the tree species can be plotted and counted. Suppose you were in a forest counting wild black cherry tree seedlings in a quadrat. You counted 40 cherry seedlings in a particular quadrat. What is the density per square meter? $D = \frac{N}{S}$ or $D = \frac{40}{100}$. Thus, $D = .4$ cherry seedlings per square meter.

When studying population density, ecologists realize that density may change, often quite swiftly and dramatically. If a lumber company cut 1000 trees in a forest, this would decrease the density. On the other hand, the germination and growth of last season's seeds would, in time, increase the density in that same forest. Both births and deaths cause changes in living populations. Ecologists call the birth rate of a population **natality** and the death rate **mortality**.

In animal populations two factors besides natality and mortality can affect density. For example, in a flock of geese on a wildlife refuge, the density could vary as more birds migrated in or as others left the flock for better feeding grounds elsewhere. The arrival of new individuals to a population from other places is termed **immigration**. The leaving of individuals from a population is called **emigration**.

List the two factors that increase the density of a goose population.

1. ______________________________ 2. ______________________________

List the two factors that decrease the density of a goose population.

1. ______________________________ 2. ______________________________

The four factors that influence the density of an animal population interact to control the size of the population. As long as the variables that influence the decrease and increase in density are balanced over time, the population will remain fairly stable or balanced.

What are some of the factors that might influence mortality, natality, immigration, and emigration? This question becomes more important as we study the specific interactions between living things, and between living things and the nonliving factors in their environment.

____

____

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____

Problem No. 3

Estimating the Density of Water Lettuce

In the photograph on page 16, you viewed a population of water lettuce. Water lettuce plants will sometimes cover the entire water surface of the swamp. The plant population becomes very dense and serves as a habitat for many insect and spider species. Use the photograph to help you accomplish the following tasks.

1. Devise a method to estimate the number of individual water lettuce plants. Be sure to include the small plants as well as the larger ones.

   Method: ____________________

   ____

   ____

   Estimation: ____________________ water lettuce plants

2. Calculate the density of the water lettuce plants shown in the photograph. The actual space covered by the plants pictured is 2.8 square meters. Since the plants grow only on the water's surface, you need not deal with cubic units.

   Density $= \frac{N}{S}$ Density = __________ per square __________

3. Compare your density estimate with those of your classmates. What was the class average? How close was your estimate to the average? What does this tell you about the accuracy of an estimate?

   ____

   ____

   What other method other than estimation could you use to improve your accuracy? ____________________

4. The water surface area of the entire swamp was measured by an ecologist during the same year the photograph was taken. The area was 2500 m^2. Assume that the water lettuce covered the entire surface. On the basis of your density estimate or your more refined technique (Item 3 above), what is the size of the swamp's entire water lettuce population?

   Entire Swamp Population = ____________________

5. Another ecologist was interested in a particular water spider population that lived on the water lettuce plants. A careful count of spiders found on 100 plants revealed an average of 0.82 water spiders per water lettuce plant. What is the population density of water spiders per square meter in the swamp? ____________________

(continued)

(Problem No. 3 continued)

If you wished to know the population density of water spiders in the entire swamp, how would you calculate it? ____________________

If the density of water lettuce plants was affected by a high winter mortality, what might be the resulting effect on the water spiders?

____

It should now become clear to you that population density figures benefit ecologists in understanding the types of interactions as well as the degree to which such interactions will take place in the environments the ecologists study. The study of populations, their densities, and the factors influencing the densities under study often enable ecologists to predict future environmental interactions.

Problem No. 4

Measuring Classroom Density

Human populations have density levels just like other organisms. People can move about, which is something some other animals and many plants cannot do. The characteristic of locomotion often produces interesting changes in population density.

1. Calculate the student population density of your science classroom. In obtaining the units of space occupied by the population, measure your room in meters. Remember that you will be using square meters of space.

   Density $= \frac{N}{S}$ Density = ____________________ per square meter
2. Repeat these calculations for each classroom you go to today. Which classroom has the highest density? The lowest?

   ____

   ____
3. Does the population density of your science classroom remain the same each day? Graph the daily densities for one week. Plot your data on the graph paper supplied in the back of this book. Refer to page 126 in the Guide for a sample classroom population density graph.
4. How can you account for the daily changes in the population?

   ____

   ____

APPENDIX B, XII
Climatographs

Climatographs
Objective: Learn to construct and interpret climatographs

Materials: graph paper, ruler, colored pencils

Prediction: Write a prediction about the advantages of using climatographs instead of tables to analyze data.

Procedure:
1. Average monthly rainfall and temperatures are given for four distinct biomes. Create a graph with rainfall on one axis and temperature on the other, so that all points from each biome are included.
2. For the first biome, plot the rainfall and temperature for each month given, labelling each point with the month's name or number. For example, you can label March or 3.
3. Connect the points for the biome in order of the months with a colored pencil. It should form some sort of circular or figure eight type pattern.
4. Repeat steps #2 and 3 for the other three biomes, using a differently colored pencil each time. When you are done, you should have four different colored patterns.

Data:	Month	Mean Monthly Precipitation (cm)	Mean Monthly Temperature (°C)
ARID CLIMATE	Jan	1.5	8
	Feb	1.5	13
	March	1.5	17
	April	1.0	22
	May	0.5	27
	June	0.5	30
	July	0.5	35
	Aug	1.5	32.5
	Sept	2.0	25.5
	Oct	2.0	15.5
	Nov	1.5	10.5
	Dec	1.5	9
ARCTIC CLIMATE	Jan	1.5	-13
	Feb	1.5	-10
	Mar	1.5	-5
	April	2.0	0
	May	3.5	5
	June	4.5	9
	July	5.0	10
	Aug	5.0	5
	Sept	4.5	-2

continued on next page

APPENDIX B, XII

	Month	Mean Monthly Precipitation (cm)	Mean Monthly Temperature (°C)
ARCTIC CLIMATE	Oct	4.0	-4
	Nov	3.0	-8
	Dec	2.5	-9
TEMPERATE HUMID	Jan	7.5	-2
	Feb	6.5	-1
	March	7.0	6
	April	9.0	14
	May	12.5	20
	June	12.5	26
	July	12.0	30
	Aug	10.5	27
	Sept	10.5	20
	Oct	10.5	10
	Nov	10.0	5
	Dec	9.0	-2
TROPICAL HUMID	Jan	19.0	26
	Feb	19.0	29
	March	18.5	32
	April	17.5	33
	May	16.5	33
	June	15.0	34
	July	14.0	33
	Aug	13.0	30
	Sept	14.0	27
	Oct	15.0	26
	Nov	17.0	26
	Dec	18.0	26

Analysis:

1. For each biome, what is the month with the highest rainfall?

2. What month is the coldest for each biome?

3. What two biomes appear to be most similar in terms of rainfall? in terms of temperature? Explain.

Conclusion:

Make a statement that summarizes each biome's climate. What advantages are there from arranging the data in this fashion?

Written by: Jill M. Evers, adapted from actual climatograph data

EnviroSci
JMEvers

APPENDIX B, XIII
Owl Pellet Study

LAB-AIDS® #37 OWL PELLET STUDY

Student Worksheet and Guide

Pellets, or castings are accumulations of the undigested portions of food items consumed by owls and regurgitated as a compact mass through the mouth. They contain hard, not easily digested materials of comparatively little nutritional value to owls — the bones, beaks, claws or teeth of mammals, birds, reptiles, amphibians and fishes; the headparts, thorax or wing cases of insects; seed husks and other coarse vegetable materials. These hard parts of food items are usually enclosed by softer, but indigestible substances such as the fur, bird feathers and vegetable fibers. Thus, the pellet is often characteristic and provides valuable clues about the type of prey.

Purpose:

1. To dissect one complete owl pellet
2. To attempt to identify the animals whose skeletons are found in the pellet.
3. To compare various bones of the mammalian skeleton
4. To construct a food chain with the owl at the highest trophic level.

Procedure:

1. Work in teams or as your instructor advises.
2. Place a pellet on a sheet of white paper
3. Record the size of the pellet:

   length ______________ and width ______________

4. Using the teasing needle (and any other tools provided) separate the bones of the animals from fur and feathers. Sometimes it may be better to soak the pellet in a dish of warm water to separate the dried fur and feathers from the other remains. If this is done, place each individual item on clean paper toweling for examination.
5. Clean the bones of debris and sort them according to type. Clean the skulls as thoroughly as possible since these are the best bones for food prey identification.
6. Use the skulls pictured on the reverse of this worksheet to identify the genera of the food prey. Record the kinds and numbers of animals found in your pellet.

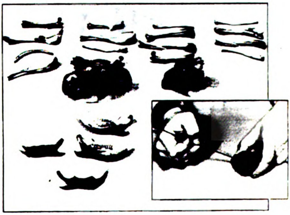
	Microtus	*Sorex*	*Scapanus*	*Rattus*	*Peromyscus*	*Mus*	*Bird*		
Kind									
Numbers									

7. Record your findings of kinds and numbers of food prey in the data chart and on the chart on the chalkboard. After the class is complete copy the final data in the data chart.
8. Identify some of the larger bones from your pellet by using the picture of the skeleton of *Microtus* sp., a vole. Now compare these bones with homologous bones of another kind of mammal found in pellets. You might also wish to compare bones found in pellets with bones of the human skeleton.

Observations:

1. Number of skulls (or pairs of jaw bones) found in your pellet. ______________________
2. Kind and numbers of animals found in your pellet.

Kind of Food Prey	Individual Numbers
______________	______________
______________	______________
______________	______________
______________	______________



APPENDIX B, XIII

3. **Class Record.**

   Total number of pellets examined ________________

   Average number of prey animals/pellet ______________

4. Assume one owl produces one pellet per day, what is your estimate of the annual food consumption of a particular barn owl?

   ____

5. How accurately do you think the content of owl pellets reflects the proportion and abundance of the small mammals in the area this pellet was collected? ____

   ____

6. Environmentalists are concerned about the accumulation of certain poisons in the systems of predators. Why do you suppose owls, eagles, swordfish, humans and lions are often the most threatened organisms of a community that is exposed to DDT or mercury? ____

   ____

Sorex

Microtus

Mus

Scapanus

Peromyscus

Rattus

OPTIONAL:

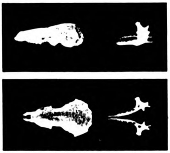
7. On a separate sheet of paper, draw a diagram of a food web in which the barn owl is positioned at the highest trophic level. Make your diagram as comprehensive as possible Use dotted lines to indicate uncertain relationships.

Name ____ Date ________________

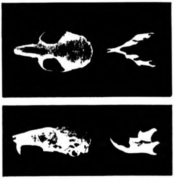
APPENDIX B, XIII

IDENTIFICATION GUIDE

REDBACK VOLE (Clethrionomys)



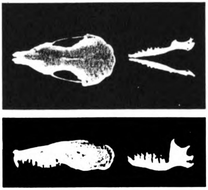
SHREWS (Soricidae)



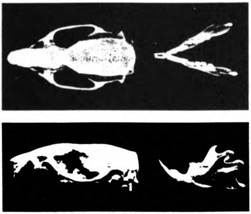
WHITE-FOOTED MICE (Peromyscus)

HOUSE MOUSE (Mus)

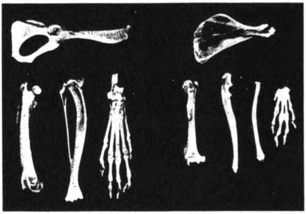
MEADOW VOLE (Microtus)



MOLES (Talpidae)



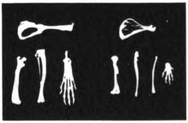
NORWAY RAT (Rattus)



RAT LONG BONES
(left to right)

Top: Innominate, Scapula

Bottom: Femur, Fibula & Tibia, Hind foot, Humerus, Ulna, Radius, Front foot



HOUSE MOUSE LONG BONES
(left to right)

Top: Innominate, Scapula

Bottom: Femur, Fibula & Tibia, Hind foot, Humerus, Ulna, Radius, Front foot

APPENDIX B, XIII

Dental Formulae

		Incisors	Canines	Premolars	Molars	U & L	Total
SHREWS							
Sorex, Microsorex,	U	3-3	1-1	3-3	3-3	20	
Blarina	L	1-1	1-1	1-1	3-3	12	32
Notiosorex	U	3-3	1-1	1-1	3-3	16	
	L	1-1	1-1	1-1	3-3	12	28
Cryptotis	U	3-3	1-1	2-2	3-3	18	
	L	1-1	1-1	1-1	3-3	12	30
MOLES							
Scapanus, Condylura,	U	3-3	1-1	4-4	3-3	22	
Parascalops	L	3-3	1-1	4-4	3-3	22	44
Scalopus	U	3-3	1-1	3-3	3-3	20	
	L	2-2	0-0	3-3	3-3	16	36
WHITE FOOTED MICE							
Peromyscus	U	1-1	0-0	0-0	3-3	8	
	L	1-1	0-0	0-0	3-3	8	16
VOLES							
Microtus,	U	1-1	0-0	0-0	3-3	8	
Clethrionomys	L	1-1	0-0	0-0	3-3	8	16
OLD WORLD MICE							
Mus	U	1-1	0-0	0-0	3-3	8	
	L	1-1	0-0	0-0	3-3	8	16
OLD WORLD RATS							
Rattus	U	1-1	0-0	0-0	3-3	8	
	L	1-1	0-0	0-0	3-3	8	16

NOTE: White Footed Mice, Voles, Old World Mice and Old World Rats have the same dental formula

PELLET DATA

Length-
Diameter-
Mass-

PREY ITEMS IDENTIFIED

Type	No. of Skulls
Voles	
Mice	
Shrews	
Moles	
Rats	
Birds	

Type	No. of Long Bones
Innominate	
Scapula	
Femur	
Fibula	
Tibia	
Humerus	
Ulna	
Radius	

Connecticut Valley Biological Supply Company
Southampton, Massachusetts

APPENDIX B, XIV
Seeds: Food for Animals?

Teacher's Guide to

SEEDS: Food for Animals?

Developed by:	Denise Akom	Pontiac Central High School; Pontiac, MI
	Cheryl Hach	Kalamazoo Area Mathematics and Science Center; Kalamazoo, MI
	Laurie Vargo	Eastern High School; Lansing, MI
Tested by:	Jill Evers	Kent City High School; Kent City, MI
	Ranae Ikerd	Grosse Pointe South High School; Grosse Pointe, MI
	Susie MacArthur	Van Buren Voc-Tech Center; Lawrence, MI
	Lynda Smith	Lakeshore High School; Stevensville, MI

BACKGROUND INFORMATION: Consider purchasing the sunflower seeds and/or peanuts for this activity in bulk and/or requesting a discount from a friendly supermarket. Sunflower seeds used for birds are small and hard to detect. Large seeds processed for human consumption work better since they are bigger and have more predominant stripes making them more visible. Golf tees may be found in surplus markets, or area golf courses often have bushels of them. Wire stakes may be used in place of survey flags; these can be made from stiff wire cut in 30 cm lengths and tied with colored, plastic ribbon. Plastic or painted, wooden popsicle sticks may also be used. Measuring tapes could be made from lengths of rope or twine that have been pre-measured and marked.

If you are considering the use of a wooded area near an urban or suburban school, consider that enough area must surround each "parent" tree such that students' experimental areas do not overlap with each other. If there is a likelihood that the grounds crew may be mowing, speak to them and try to arrange a time that this exercise will not interfere with the yardwork. If a densely populated woodlot is used for this exercise, the treatment areas should be checked almost daily.

You may want to consider using the data obtained from this exercise to find statistical significance using a chi-square calculation, comparing treatments a and b. In this way, students can be given the opportunity to analyze experimental data using a mathematical approach. The calculations are not complicated, but the theory and explanation of significance may require a great deal of time. Perhaps this could be undertaken jointly with a math teacher as an interdisciplinary task.

OBJECTIVES: To determine the effect of distance from a parent tree on seed predation

To practice writing null and alternative hypotheses

To practice experimental methods in the "real world"

SUGGESTED HYPOTHESES

H_0: The distance of the seeds from the parent tree has no effect on levels of predation.

H_1: The further the distance of the seeds from the parent tree, the less predation that takes place.

QUESTIONS:

1. Is distance a determining factor for seed survival? Use the data from treatments a and b to propose an alternative hypothesis.

2. What do your results suggest about the behavior of seed eating animals?

3. Propose 3 reasons why animals may have eaten more seeds from one treatment site as compared to another.

FURTHER INVESTIGATIONS: Different types of seeds can be substituted in this experiment. Likewise, different groups could use different seed types to see if predators exhibit a preference. Students may be encouraged to develop experimental protocols using different variables or testing more refined hypotheses.

Seed density can also be addressed in addition to distance from a parent plant. Seeds can be spread out more or clumped in a concentrated area at various distances from the chosen tree.

An interesting extension question, suggested by the source of this lab, Dr. Kathy Winnett-Murray of Hope College, involved a discussion regarding the evolution of seed plants. Why don't all seed plants produce fruits that will be eaten by predators? What evolutionary factors might select against the evolution of such efficient dispersal mechanisms? Although this would take a lot of class discussion, if time is available, it could be time very well spent.

REFERENCES:

Howe, H.F. and J. Smallwood. 1982. Ecology of Seed Dispersal, Annual Review of Ecology and Systematics, 13:201-228.

Winnett-Murray, K. 1993. Frontiers in Biology lecture, Biological Diversity and the Tropical Rain Forest. Michigan State University.

APPENDIX B, XIV

SEEDS: Food for Animals?

TO THE STUDENT: One of the purposes of this laboratory exercise is to develop an understanding of the scientific method and an appreciation of its practical applications to everyday problem solving.

INTRODUCTION: Nearly all species of animals and plants have some means of dispersing their offspring. Among animals, offspring such as spiders can be carried by the wind while aquatic invertebrates commonly use water currents. Many offspring may disperse under their own power voluntarily or involuntarily. Animals of all types encourage their offspring to leave the "nest".

Among plants dispersal is usually passive, but it may take place by a variety of techniques. Some plants use abiotic or nonliving means for dispersing their seeds. Examples include maples, ashes, dandelions, and milkweed which use wind currents to disperse seeds away from the parent plant. Other plants, such as cocklebur, thistle, and sticktight produce seeds that stick to animal fur. In this way the animals unknowingly carry the seeds to other locations. Still other plants produce seeds that will be dispersed in animal droppings. Plants of this type usually encourage this dispersal through the formation of fleshy fruit pulp that is tasty. This is a trade-off where the plant produces an energy expensive fruit for the animal to eat in return for the seeds remaining intact and being spread farther away than the "parent" could have accomplished on its own.

How does seed dispersal benefit a plant species? Dispersal could increase survival of offspring by spreading seeds over a large area so that predators may have to hunt to find them. Getting the seeds away from the parent may also result in a greater number of seeds encountering favorable conditions; for example, seedlings may not germinate in the shade of the parent. Dispersal can also result in the movement of seeds to sites where the probability of germination is especially high, such as those seeds found in animal droppings which have contact with a highly organic environment.

In this exercise, we will set up an experiment using sunflowers and/or peanuts to determine whether seeds removed various distances from a "parent" tree suffer different losses from seed predators. Many animals use trees as their homes or at least as a source of protection or escape from bigger animals that may feed on them. Certain animals may recognize the tree as a potential food source and may search near it. Conversely, animals which happen to live away from the "parent" yet near the seeds, would make those seeds further from the tree more likely to fall prey to the animal.

HYPOTHESIS: Write 2 hypotheses as to how distance from a "parent" plant relates to predation. Choose the one you think is best.

MATERIALS: (per group)
20 golf tees
200 sunflowers, or 100 peanuts, or
 50 peanuts and 100 sunflowers

APPENDIX B, XIV

20 meter measuring tape
2 surveying flags
ribbon
marker

PROCEDURE:

DAY 1

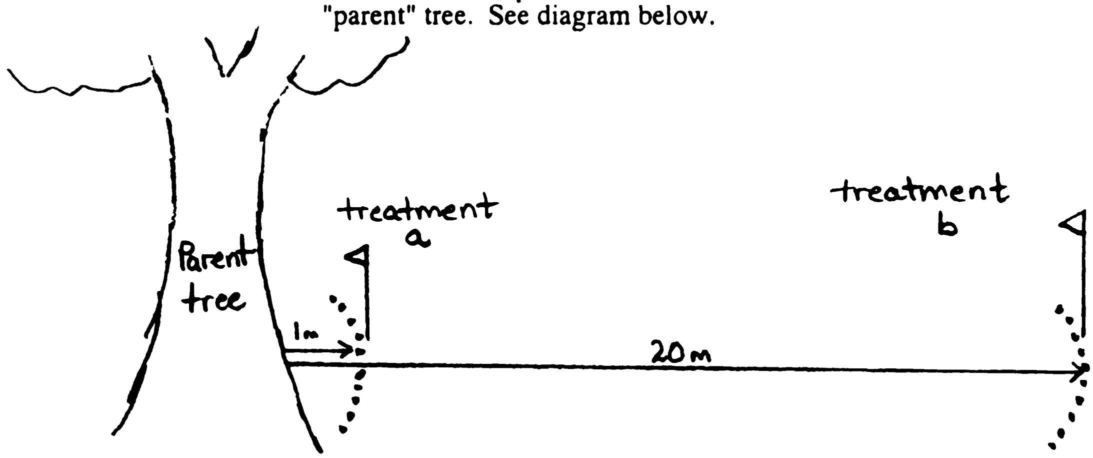
1. Each group should choose a "parent" tree which is located 100 meters from another group's "parent" tree.

2. Mark your tree by wrapping it with a marked ribbon.

3. Distribute the "prey" (seeds) as follows:

   Treatment a. Put 10 golf tees in an arc one meter from the "parent" tree. Push in the tees so that only 1-2 cm is above the ground. Count out 10 sunflower seeds (or 5 peanuts) and place them on and next to each tee. Mark the general vicinity with one of the flags. See diagram below.

   Treatment b. Repeat treatment a at a distance of 20 meters from the "parent" tree. See diagram below.



DAY 2 OR 3

4. Count the seeds/nuts remaining at each site, and record the data in the results table provided.

DAY 4 OR 5

5. Count and record the results again in the appropriate columns.

6. Remove the ribbon, tees, and flags from your experimental environment. Count your supplies to make sure you have everything.

7. Determine the numbers of seeds/peanuts removed and remaining for each of the experimental treatments. Pool your data with the rest of the class.

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RESULTS:

	Day 2/3	Day 2/3	Day 4/5	Day 4/5
	# Gone	# Remaining	# Gone	# Remaining
Treatment a				
Treatment b				

CONCLUSIONS: Analyze the data collected. Accept or reject your chosen hypothesis on the basis of the collected data. Be sure to explain your reasons for accepting or rejecting the hypothesis.

APPENDIX B, XV
Measuring Toxicity Levels of Chemicals using a Seed Germination Bioassay

Teacher's Guide to Measuring Toxicity Levels of Chemicals using a Seed Germination Bioassays

Developed by:

Michael S. Hoekwater — Calvin Christian High School, Grandville, MI

Tested by:

Jill M. Evers — Kent City High School, Kent City, MI
Ranae Ikerd — Grosse Pointe South High School, Grosse Pointe, MI
Susie MacArthur — Van Buren VoTech Center, Lawrence, MI
Lynda Smith — Lakeshore High School, Stevensville, MI

BACKGROUND INFORMATION: 1 M NaCl solution preparation: To make one liter, weigh 58.8 g (formula weight) into a flask, and bring this up to a volume of one liter. Use this as the 100% salt solution. Students will make their own serial dilutions using this 100% salt solution.

10% Bleach solution preparation: Mix one part full strength bleach with 9 parts water (ie. 100 ml bleach with 900 ml water)

Mustard and lettuce seeds were used in this experiment. Other seeds, such as Wisconsin fast plants, will work, provided they are small. Radish seeds might be avoided as their seed coat is quite tough. Mustard seeds are hardest to apply to the wick because of their low surface area, being quite round in shape. Lettuce seeds are easy to apply and stick well. Both mustard and lettuce seeds have a 7-10 day germination period. However, under these conditions some seeds began to germinate in 1-2 days. A week should allow enough time for the whole experiment. Remember to obtain seeds in the spring when they are readily available, and at least 5 seeds should be applied to each wick to establish a percent germination.

The vials that were used in testing were 20 ml scintillation vials. A local film processing outlet or camera store may be the source of film cans if other small vials are not available. Clear plastic works well in this experiment, but dark plastic will work. Seeds will just appear anemic if they are kept in the dark.

Pellon is available at fabric stores and is quite inexpensive. Pellon must be washed and double rinsed before being used. Washing removes chemicals used in the manufacturing process which are toxic to the germinating seeds. Other absorbent fabrics can be used. Wicks should be approximately 1.5 cm wide and 8 cm long. Students could cut their own.

SUGGESTED HYPOTHESES: Salt concentrations will have no effect on seed germination.

Fewer seeds will germinate in salt solutions of increasing concentration.

More seeds will germinate in salt solutions of increasing concentration.

APPENDIX B, XV

QUESTIONS: If the students are not accustomed to writing conclusions as the lab directs, you may want to lead them to the proper method for this by using the following questions. It is recommended, however, that students learn to write their own conclusions without this type of help.

1. How did seed germination change as the concentration of salt increased?

2. What concentration of detergent appears to be the acceptable "limit" for these seeds before they will no longer germinate? Did all groups in the class find the same limit?

3. Why are there five seeds on each wick rather than one? Is it just to create more work?

EXTENSIONS: 1. Other substances, such as heavy metal ions, detergents, or pesticides can be tested. No germination was found in 25% or higher detergent solution.

2. Other plant seeds can be used. Compare the seed germination of two different plants using the same chemical.

3. Multiple seeds of different plants could be placed on the same wick to see if some seeds inhibit the growth of others.

4. Some substances are supposedly biodegradable. This could be investigated by using a bioassay to test any changes in their harmful effect over a period of time.

APPENDIX B, XV

Measuring Toxicity Levels of Chemicals using a Seed Germination Bioassay

TO THE STUDENT: One of the purposes of this laboratory exercise is to develop an understanding of the scientific method and an appreciation of its practical applications to everyday problem solving.

INTRODUCTION: A bioassay is a technique used to determine the effects of substances on living organisms. A substance is tested at various concentrations with living "test" organisms to determine what concentrations are beneficial or harmful to the organisms. The pharmaceutical industry evaluates new medicines by measuring the quantity of a drug that results in a defined effective dose.

One standard measurement of the toxicity of a substance is the lethal dosage that causes death to fifty percent of the test organisms. Lethal dosage is expressed in milligrams of chemical needed per kilogram of body weight of the organism. Therefore, if less is needed to kill the organism, the lower the lethal dosage for a substance and the greater the toxicity.

There may be visual or measurable symptoms of toxicity at sub-lethal levels. Organisms that are sensitive to a particular substance can be used as indicator species for the presence of that substance. The Environmental Protection Agency (EPA) has begun using plants, in addition to animals, to test the toxic effects of materials in the environment. Tobacco plants are now being used to detect atmospheric ozone.

A simple bioassay with plants examines the effects of a substance on seed germination. In this lab, you will be measuring the effect of increasing concentrations of a salt solution on seed germination. The concentrations will range from 0% to 100% 1M salt solutions.

HYPOTHESIS: Write three hypotheses concerning how increasing concentration of salt will influence seed germination. Choose the one you think is best.

MATERIALS: (per group)
45 small seeds, such as mustard, lettuce, parsley
9 plastic 20-40 ml vials; or plastic 35 mm film cans; or even 50 ml beakers
9 wicks made of pellon (absorbent fabric) , 1.5 cm x 6 cm
Large beaker, >1000 ml
1 M NaCl solution
Permanent marker
Plastic wrap or aluminum foil
Ruler
10% Bleach solution

CAUTION: Some seeds are pretreated with fungicides so do not eat them and wash your hands after handling them.

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PROCEDURE:

1. Wipe down the entire lab area to be used with a 10% bleach solution to help clear the area of various molds etc. This may help prevent a red fungus from growing on the wicks.

2. Using a ruler, mark a one-half full line and a full line with a permanent marker on each vial.

3. Label one vial 0% = water, and the other eight as follows: 0.78%, 1.56%, 3.13%, 6.25%, 12.5%, 25%, 50%, and 100%.

4. Fill the 0% (water) vial to the one-half full line with water.

5. Fill the 100% can to the one-half full mark with the 100% 1M NaCl solution.

6. Fill the 50% vial to the lower mark with the 100% solution. Add water to the 50% vial to the full mark. Mix well. This vial now contains a 50% solution.

7. Making sure the liquid in the 50% can is completely mixed, pour one-half into the 25% vial. Add water to the 25% vial to the full mark and mix, making a 25% solution.

8. Repeat this same procedure until all the vials are prepared. This is called a serial dilution.

9. On the final vial (0.78%), pour off one-half of the salt solution so all vials are at the same level.

10. Insert wicks into all 9 vials. You may need to push the wicks down into the salt solutions to hasten the wetting process. When the wicks are moist at the top, place five seeds on each wick. They should stick.

11. Place the 9 vials inside the large beaker around the edge. Place the "water" can in the center. Place some plastic wrap or foil loosely over the beaker and label your container with your name, the date, and the type of seeds used.

12. For the next 3-5 days, observe the seeds in the vials each day. Determine which seeds are germinating. (The seed coat is splitting and the root is emerging.) Record in a data table the concentration of salt and how many seeds have germinated (zero to five). Note also the appearance or apparent health of the seeds that may be struggling to stay alive.

CONCLUSIONS:

Carefully analyze the data collected. Accept or reject your chosen hypothesis on the basis of the data you collected. Be sure to explain your reasons for accepting or rejecting the hypothesis on the basis of observable and tabulated data.

Teacher's guide to Estimating the Carrying Capacity for Gray Squirrels

Developed by:

Michael S. Hoekwater	Calvin Christian High School, Grandville, Michigan

Tested by:

Jill Evers	Kent City High School Kent City, Michigan
Ranae Ikerd	Grosse Pointe South High School Grosse Pointe, Michigan
Susie MacArthur	Van Buren Voc-Tech Center Lawrence, Michigan
Lynda Smith	Stephensville-Lakeshore High School Stephensville, Michigan

OBJECTIVES: Calculate the carrying capacity of squirrels in a wooded lot of oak trees.

Compare the carrying capacity of squirrels in a wooded lot of oak trees to that of oaks in a city park area.

HYPOTHESES: The wooded lot will have a greater carrying capacity than the city lot.

The city lot will have a greater carrying capacity than the wooded lot.

There will be no difference between the carrying capacity of a city lot and a wooded lot.

BACKGROUND INFORMATION: The data for this activity applies to the gray squirrel. However, the fox squirrel may be more common in your area. Since these two squirrels are very similar in size and in their activities, the data can be assumed to be accurate for both species.

You will need to find a wooded lot with oak as the predominant species and a city lot with a few oak trees. If a city lot is not available in a rural area, a stand of roadside trees may be used. The area does not have to be very big but keep both comparative areas equal in size.

It is recommended that you perform this laboratory when leaves are on the trees for ease in identification. You could stake out the area before the students arrive depending on the time that can be dedicated to the activity. Other sized plots could be used. If the lots are large, several classes' data may need to be tabulated to find the carrying capacity for the entire lot.

The following information is needed for calculating carrying capacity:

One squirrel needs 137 kilocalories/day or 50 005 kilocalories/year for its survival diet.

Emphasize to the students that this information is an average estimate for squirrels.

Depending on the selected sites, the carrying capacity may be greater in the city or in the wooded lot. The age or size of the trees is the most significant factor in determining the carrying capacity. In some cases, the trees in a residential area may be larger in circumference than those in a wooded area because of the age or because there is less competition from other trees.

The calculated carrying capacity is based on the assumption that squirrels are getting all of the oaks' acorns. Other wildlife may use acorns as food. Some organisms whose diet is comprised of 25 to 50% acorns are the black bear, raccoon, white-tailed deer and the wild turkey. Other animals that may eat acorns are the bluejay, common crow, cottontail rabbit, mallard duck, pintail duck, red fox, red squirrel, ring-necked pheasant, ruffled grouse, starling, white-breasted nuthatch.

Be sure to include Figures and Data Tables when duplicating protocols for your students. You may want to simplify by eliminating types of oaks in your tables.

APPENDIX B, XVI

SAMPLE DATA TABLES AND KEYS:

Figure 1.
Circumference and Yearly Average Acorn Crop of Oaks in Kilograms*

Diameter at breast height (cm.)	Northern Red	Scarlet	White
78.5	0.18	1.10	0.85
94.2	0.99	1.80	1.60
110	2.60	2.50	2.30
126	4.50	4.60	3.10
141	6.50	5.40	3.90
157	7.10	6.60	4.60
173	7.70	7.90	5.40
188	6.90	8.00	6.10
204	6.20	8.20	6.80

*Adapted from U.S. Department of Agriculture. Forest Service, *Managing Woodland for Wildlife*, 1970

APPENDIX B, XVI

Figure 2.
Student Guide to Identification to Oak Species

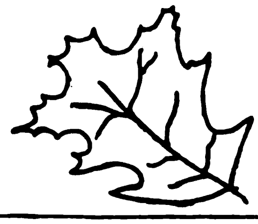
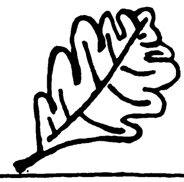
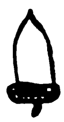
Oak Type	Northern Red	Scarlet	White
Name	*Quercus rubra*	*Quercus coccinea*	*Quercus alba*
Leaf			
Leaf Description	Deeply cut with bristle-tipped points	Smooth with deeply cut lateral lobes, sides tending to be incurved, forming rounded spaces between lobes	Rounded lobes separated by deep clefts
Acorn			
Acorn Description	Ripen in two seasons. Large with shallow cups. Approximately 2cm long	Cup 1/3 to 1/2 the length of the 1.3 to 2.2 cm nut. Cup closely overlapping scales, not forming a fringe. Often in pairs.	Ripen in autumn of first season. Cup covered with thin, flat scales near the rim and more knobby scales at the base.
Bark Description	Young trees-smooth, shiny gray to brown. Older trees-darker with shallow fissures and firm, broad ridges.	Light brown to black with irregular ridges separated by shallow furrows.	Easily scuffed. Thick, light gray or whitish old trunks with fissures into broad, firm ridges.

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Figure 3.
Sample Data Sheet

Circum-ference	Number of White Oak Trees	Number of Northern Red Oak Trees	Number of Scarlet Oak Trees	kg of acorns White Oak	kg of acorns Northern Red Oak	kg of acorns Scarlet Oak	Total Kilograms
78.5	.85						
94.2	1.6						
110	2.3						
126	3.1						
141	3.9						
157	4.6						
173	5.4						
188	6.1						
204	6.8						
						Grand Total	

QUESTIONS: If the students are not accustomed to writing conclusions as the exercise directs, you may want to lead them through this by posing the following questions. It is recommended, however, that students learn to write their own conclusions.

1. Identify reasons why the actual number of squirrels in the woodlot may be different from the calculated carrying capacity of the woodlot.

2. What assumptions must be made in this investigation concerning how to calculate the squirrel carrying capacity ? What other factors should be included in the calculation to make it more accurate?

3. If data from another class is available, why might their acorn yield be different from yours?

4. A deer weighing 55 kilograms needs 3232 kcal/day. If the deer ate only acorns, how many days worth of food for the deer would your area supply in a year's worth of acorn production?

5. Why is it better to use the lower number if a tree's circumference falls between two of the tabulated values rather than rounding up or down?

REFERENCES: Butterfield, Charles H. 1979. Estimating the gray squirrel carrying capacity of an acre of oaks. *The American Biology Teacher* 41(6):332-354

Ludwig, R.L. Fontenat, J.P. and Mosby, H.S. 1969. Energy metabolism of the eastern gray squirrel. *Journal of Wildlife Management* 33(3):569

Managing Woodland for Wildlife. 1970. U.S. Department of Agriculture, Forest Service

Otis, Charles Hubert. 1978. *Michigan Trees*, University of Michigan Press, Ann Arbor, Michigan

APPENDIX B, XVI

Estimating the Carrying Capacity for Gray Squirrels

TO THE STUDENT: One of the purposes of this laboratory exercise is to develop an understanding of the scientific method and an appreciation of its practical implications to everyday problem solving.

INTRODUCTION: How many squirrels can live in a certain wooded lot of oak trees? Is the number of squirrels that can be supported in a city lot greater than or less than that of the same-sized lot in a forested area? Answering these questions requires some understanding of what controls the size of a population in a given area.

In any ecosystem, certain factors will limit the size of a population that can be supported in the area. This population is called the carrying capacity of the ecosystem for this species. Food supply, crowding, waste accumulation, the interaction of organisms, and climate all help determine the carrying capacity of an ecosystem. Although all of these factors are important, perhaps the most important limiting factor is the food supply.

In this experiment, you will be comparing the estimated carrying capacity of a wooded lot of oak trees to an equal-sized area in a city lot. To simplify your computations, only the food supply factor will be considered when making your estimations. By knowing how much food a squirrel needs to survive, and knowing how many acorns a lot makes, an estimate of the squirrel carrying capacity of an area can be made.

HYPOTHESES: Write three hypotheses about the carrying capacity of squirrels in a forested area compared to that of a city lot. Choose the one you think is best.

MATERIALS:
Tape measure
Calculator
Data Charts

PROCEDURE: 1. Assist the class as instructed in measuring a plot 10 m^2 by measuring a square that is 10 on each side. Place flags at the corners of each of the squares.

2. Begin on one side of your plot and work your way to the other side. When you identify a tree as being an oak (use the picture of the leaves to help identify oaks) measure the circumference of the tree at breast height using the tape measure. Make a tick mark on your data sheet for each species of oak opposite the appropriate circumference. If a measurement falls between two numbers, record it opposite the lower number to obtain a conservative estimate. Mark each tree that has been counted with a flag. Continue identifying, marking, and tallying for your entire plot.

3. Recheck the area, ensuring all trees have been recorded. Remove the flags and markers.

`4. Repeat steps 1-3 at the alternative site. Make sure to record your data on an alternative data sheet.

5. Pool your data with other people in your group. When the group's data has been compiled, multiply the total number of each tree species of a given size by the average production figure given in Figure 1. (For example, if the total number of white oaks with a circumference of 94 cm is 8, then the mass of the acorns is 1.6 kg/tree multiplied times 8 trees resulting in a total of 36.8 kg). Fill in all totals on the data table.

6. Convert the total acorn yield in kilograms to kilocalories. One kilogram of plant matter is assumed to produce around 4500 kcal/kg or 4.5×10^3 kcal/kg. (For example: 22.0 kg acorns x 4.5×10^3 kcal/kg = 9.9×10^4kcal or 99 000 kcal).

7. Write your group's grand total on the data table your teacher provides so the entire section's data can be compiled.

8. What additional data is needed before you can compute the number of squirrels that can be supported in each of the surveyed areas? Your teacher will supply you with this information. Use it to calculate the carrying capacity of squirrels in both lots.

CONCLUSIONS: Carefully analyze the data collected. Accept or reject your hypotheses on the basis of the data collected. Be sure to explain your reason(s) for accepting or rejecting the hypotheses on the basis of observable and tabulated data.

APPENDIX B, XVII
Soil Science Experiment--Testing Abiotic Factors

SOIL SCIENCE EXPERIMENT--Testing abiotic factors of soil

*Pre-lab demonstration--You will be shown the proper technique for taking soil cores with a soil sampler/corer.

Problem: Are all soils the same?

Hypothesis: Write two hypotheses that you could prove. Circle the one you believe will be correct.

Materials:

Soil corers	Rapid Soil Test Kits
Plastic bags	Paper lunch bags
Pipettes	Screens/sieves
Beakers/jars	Balances
Gloves	Scissors
Incubator	Permanent markers or tape

Day One: Working in groups, you will take soil samples from three locations--the lawn, the field just north of the school, and the woods behind the school. Go to the first location with your group and your supplies.

1. "Wash" or "flush out" your soil corer by taking a sample and throwing it out.
2. Take two soil cores 10 cm deep. (The corers are already marked with a piece of tape at 10 cm.) Without handling the cores with your bare hands (Wear your gloves!), place them in one plastic bag.
3. Label the bag with your location and initials using the marker or piece of tape.
4. Repeat steps 1-3 at the two other locations.
5. Return to the classroom and sift each sample with the screen sieve while still wearing your gloves. Return each sample to its marked bag.
6. Cut off and discard the top one-half of three paper lunch bags. Use these cut bags for the remainder of the lab.
7. Mass one of the paper lunch bags and record it. This is your bag mass.
8. Put 50 +/-0.2 grams of one of the soil samples into the bag and record it as the original soil mass.
9. Label the paper bag with the source of soil and your initials.
10. Repeat steps 7-9 for the other two locations.

APPENDIX B, XVII

11. Fold all three, paper bags so the soil will not spill and place these in the incubator overnight. Save the original soil samples (the plastic bags).

Day Two:
1. Retrieve your dried soil samples from the incubator. Mass each bag with the soil in it and record its new mass. This is the total dried mass.

2. Calculate the percent moisture or water for each sample using the following formula:

$$\frac{\text{original soil mass} - (\text{total dried mass} - \text{bag mass})}{\text{original soil mass}} \times 100 = \%\ H_2O$$

3. Follow the directions on the Rapid Soil Test Kit for making the soil-water mixtures in the proper ratios for each type of soil. Use the dried soil samples if you have enough. Mix the water and soil together in the beakers or jars, labelling each with the soil type and your initials.

Day Three:
1. The relatively clear liquid or top portion of each soil-water mixture is the supernatant. Using one type of soil-water mixture, transfer this liquid with a pipette into the testing vials of the Rapid Soil Test Kits. By following the enclosed directions, determine the pH, and the amount of N, P, and K available. Repeat this for the other two types of soil, using a clean pipette.
2. Record all of the levels.
3. In your lab write-up, report the following for the three types of soil: % moisture; pH; levels of N, K, and P

Questions:
1. Are all soil samples alike? In what ways are they the same or different?
2. How can you explain some of the similarities or differences that you found?
3. Do you think that you would find more similarities or more differences among your samples if some were taken from a pine forest or the edge of a swamp? from another county, state, or even a different continent? Explain your answers.
4. What human factors could possibly influence some of the values you got from the field sample?

Written by: Jill Evers, Kent City High School
EnviroSci
JMEvers

APPENDIX B, XVIII
Abiotic Factors of Water:
Ball Creek--Water Testing Experiment

ABIOTIC FACTORS OF WATER

Ball Creek--Water Testing Experiment

Very carefully, we will travel to Ball Creek, where it passes under Ball Creek, the road. Yes, this does mean we will have to park in the far side of the Kent City Lounge parking lot. Together we will walk down to Ball Creek. We will discuss what local things affect the creek's content, flow rate, and temperature after observing the area.

As a class, we will determine flow rate by calculating the amount of time it takes an object to float a predetermined distance downstream. Simple division will give us the velocity. Also, how to use a plankton net will be demonstrated and we will take samples back to the classroom for observation.

Using Hach water test kits, your group will test Ball Creek for various abiotic factors. Factors to be tested include:

DO____________ CO_2____________ pH____________

Fe____________ Cl____________ NO_3____________

hardness____________

Once at the creek, follow the directions highlighted and included in each kit. Make sure you rinse all of the glassware and plastic containers with the water to be tested before you perform the tests. Record your data in the spaces above, any diversions from the directions, and any abnormalities. Once you have completed one test, return the kit and get another.

Classroom discussion on the various levels of the abiotic factors tested will follow. You will be held accountable for what "normal" values for the different factors are and what things influence them.

EnviroSci
JMEvers

APPENDIX B, XIX
Environmental Scavenger Hunt

ENVIRONMENTAL SCAVENGER HUNT

You may choose our own partner for this activity.

Each group will need a grocery sack, notebook, and writing utensil.

All teams of two will have 35 minutes to scavenge. You need to find as many items as possible that begin with certain letters, given below. These need to be "nature" type items. For example, picking up a piece of paper will not count for the letter *T*, as in *Trash*. Instead, gather a *Twig*. Use your discretion when it is something you should not or can not pick up--*Trillium*, bird eggs, racoon, tree etc. Do collect elm leaves for E so we can verify your findings. I will be roaming around nearby if there is a question or if you want me to verify the fact that you found something you are not collecting. You must stay between the high school and woods. Anywhere along the trail is fair ground. Meet back at the designated area before time runs out; otherwise you will be penalized for going over.

Here are the letters you are to use. Write them vertically down your paper, one letter per line. Fill in what you are using for that letter. You cannot use the same item twice.

E-N-V-I-R-O-N-M-E-N-T-A-L S-C-I-E-N-C-E R U-S

There will be prizes for the winners. You may have to be creative to fill all your slots. I will be the judge as to the validity of some answers when we return.

READY, SET, GO SCAVENGE!

**Afterward, please return all organic material collected to the fence-row nearest the building. Recycle your bag.

EnviroSci
JMEvers

ACTIVITY 4: WHAT PRICE OPEN SPACE?

Activity Summary

Students assume the characters of various people in a community that is faced with a decision about what to do with a piece of undeveloped property. Each student is provided with a detailed character description and is given some information about his or her character's position on the use of the property in question. The students present their "sides" of arguments at a role-played public hearing.

Introduction

As our population increases, our cities and suburbs expand. People need places to live. For many years the American Dream has generally included a piece of property with a single family residence on it.

As cities and suburbs expand, though, open space is lost. Many people who moved to a small town to have open space nearby are soon faced with the loss of that open space as others move to the community and as homes and businesses are built on undeveloped land. People often want to lock the gate behind themselves to maintain a small-town atmosphere.

Both individuals and governmental agencies must make difficult decisions about the development of land. The rights of the individual landowner must be weighed against the benefits and problems generated by the development of a piece of property. Private profit must be considered along with the general good. Land-use decisions often have effects on people from neighboring communities. Traffic to and from a new development may affect neighbors. Recreational land is often lost. Property values may increase or decline. Schools and other governmental agencies are impacted. Wildlife, possibly including rare, threatened, or endangered species, may be lost.

Most communities have zoning or planning commissions that make decisions about the use of land in their jurisdiction. There is generally opportunity for public input on major decisions. This activity is a simulation of such a hearing.

Grouping

Character Cards are provided for 13 roles. Individual students assume each role. You can add or delete roles to suit your needs, but if more than 13 or so roles are used, it is difficult for the students to remember what was said.

Time

Three 45- to 55-minute sessions

Anticipated Outcomes

The students will:

- increase their understanding of the complexity of land-use decision making.
- increase their ability to present arguments in public.

- increase their understanding of the public-hearing process that is often used in government.

Materials

—Photocopied student pages:
- 4.1 What Price Open Space?: Background Information (one per student)
- 4.2 What Price Open Space?: Instructions (one per student)
- 4.3 What Price Open Space?: Questions (one per student)
- Character Cards (glued to index cards and laminated) (one per character)

—Props such as podium, microphones, gavel appropriate for a public hearing
—Name plates for each character (made from manila folders that have been cut and folded)

Vocabulary

development endangered species open space zoning

Teacher Preparation

1. Photocopy the Background Information sheet (4.1), Instructions sheet (4.2), Questions sheet (4.3), and Character Cards.
2. Cut the Character Cards apart and glue them to index cards. Laminate the cards.
3. Make name cards for each character. You can use half of a manila tagboard folder, folded in half lengthwise and with the character's name and role printed plainly on it.

Safety Considerations

None

Procedure:

Prior to Day 1: Either select the students for the roles or allow them to volunteer. Consider assigning the students to particular roles so that the discussion is balanced.

DAY 1:

1. Provide the students with their Character Cards. Allow them time to read their characters' roles and to jot down some notes to be used in their presentations at the hearings.
2. Explain to the class that a hearing will be held tomorrow and that everybody in the class will participate in one of the following ways:
   - Those who have been assigned roles will prepare a short presentation or talk to be given at the hearing.
   - Those who have not been assigned roles can either:

a. make up their own characters and prepare a presentation for the hearing.
b. assume the role of an expert witness who will prepare a written technical report in support of the other characters.
c. assume the role of a newspaper reporter who will be covering the hearing.
d. assume the role of a concerned observer who will subsequently write a letter to the editor of the fictitious town's newspaper.
e. assume the role of the chairperson of the hearing.

3. Have the students with assigned roles read their Character Cards to the class. This will help the other students to select their roles.
4. Allow time for questions, then allow the class to work on preparing for the hearing. Have the students without Character Cards write down what they are going to do. They should consider this a commitment and class homework. Try to have at least two newspaper reporters and several letter writers, preferably people who will write in support of different sides.

DAY 2:

1. On the day of the hearing, review the rules for the hearing, or, preferably, have the chairperson lead this review.
2. Have each of the students with Character Cards read his or her prepared testimony. Students who don't have Character Cards can ask questions of those who have testified. The chairperson's job is to keep order, and he or she must recognize the other students before they can ask their questions.

DAY 3:

1. Have the students without Character Cards read their letters, newspaper articles, or reports.
2. Allow time for questions from the commissioners.
3. Then, have the commissioners vote and give their reasons for voting as they did.
4. Finally, discuss the hearing and the issues raised.

Discussion

1. What are some of the problems that the commissioners encountered in trying to make their decision?
2. Was this activity realistic?
3. Which was more important:
   a. WHAT a person said, or
   b. HOW he or she said it, or
   c. WHO was saying it?
4. What factors influence voting by commissioners?
5. Did any of the characters change his or her mind as a result of the hearing? Did you?

6. What local governmental agency or agencies is/are responsible for decisions such as this?
7. How can you as a citizen take part in such decision making?

Answers to 4.3, What Price Open Space? Questions

1. Zoning commissioners should consider such things as the effect on traffic, pollution, crowding, jobs, taxes, and the quality of life for the current residents. (*Other factors will probably be mentioned by the students.*)
2. Answers will vary. The students should give their reasons for their choice.
3. Answers will vary, but the students should include such things as getting their facts straight, preparing their speech, practicing it, thinking about their appearance, bringing along some supporters, being on time, and so forth.
4. Once land is developed by paving and building on it, it is extremely difficult to return it to a natural state. If a species becomes extinct in the process, that species is gone forever. Soil quality, water percolation, air quality, and other environmental factors are usually permanently altered. On the other hand, not developing land now still allows for the possibility of future development if the need arises or if conditions change.
5. Answers will vary.

Extensions (See Activity 32 for suggestions for student projects.)

1. Either develop or have the students develop another similar simulation. Students who did not have Character Cards should have the main roles this time.
2. Bring in guest speakers from local planning commissions, builders' or real estate groups, environmental organizations, or other appropriate organizations.
3. Take a field trip to a planning or zoning commission hearing.
4. Visit a local undeveloped area and discuss various potential uses for it. Find out what plans, if any, there are for the site.

References

Cheryl, Dr. Charles (Project Director), *Project Wild, Secondary Activity Guide*. Boulder, CO: Western Regional Environmental Education Council, 1986.

Roa, Michael L. 1993. *Environmental Science Activities Kit*, p. 33-41. West Nyack, NY: The Center for Applied Research in Education

4.2 What Price Open Space?: Instructions

In this activity, some students in the class will take on the roles of various people at a zoning commission hearing. Some will be zoning commissioners. Others will be people who speak at the hearing. Others will have roles such as newspaper reporters, "experts" who provide reports, or concerned citizens who write letters to the editor of the local newspaper. Here is the procedure:

Day 1:

The students will be assigned their roles and begin to prepare for the hearing, which will be held tomorrow (Day 2). The roles include:

a. **hearing participants with "Character Cards":** These students will have Character Cards that describe characters that they will play at the hearing. Some will be zoning commissioners and others will be various interested parties from the community.
   Their homework is to prepare their presentations for Day 2.
b. **newspaper reporters:** These students will represent reporters who will write articles for local newspapers. At least one should be in favor of the proposed zoning change and at least one should be against it.
   Their homework is to write their articles after the hearing and be ready to read them on Day 3.
c. **expert witnesses:** These students will prepare reports to support the various viewpoints. They may write about such things as endangered species in the area, the need (or lack of need) for jobs, traffic patterns, whether there is enough water for the development, room in the schools, and so forth.
   Their homework is to write their reports and present summaries of their reports on Day 3.
d. **letter writers:** These students will write "letters to the editor" based on the hearing. They should either support or oppose the proposed development and should make reference to testimony heard in the hearings on Day 2.
   Their homework is to write their letters and present them on Day 3.

Day 2:

The chairperson of the zoning commission presents the proposal and runs the meeting. The various people with Character Cards present their cases. The rest of the class take notes and begin to prepare their letters, articles, or reports.

Day 3:

The newspaper articles, reports, and letters are presented to the commission. After meeting briefly to discuss the proposal and the community input, the commissioners vote for or against the proposal. The class will then discuss the hearing.

4.1 What Price Open Space?: Background Information

When an individual has a piece of property that he or she would like to **develop** or build on, the person generally needs to get approval from a **zoning** or planning commission. This is because what people do with their property will have impacts on others in the community.

If houses are built, there will be more people traveling the roads, more children in schools, and more need for various services such as police and fire protection. If businesses are built, there will be more traffic, waste to be disposed of, and more pollution. In any case, if undeveloped land is developed, there will be less **open space** and less wildlife habitat. Rare or endangered species may be threatened.

On the other hand, the development of the property will provide jobs for the construction workers. If houses are built, the residents will bring their skills and interests to the community, as well as increase the need for more schools, stores, and other services. If businesses are built, more jobs will be available.

In most communities, there is a general plan that has the land in the community designated or **"zoned"** for different uses such as residential, agricultural, open space, industry, and so forth. If, for example, one has some agricultural land that a person wants to build houses on, he or she would have to apply for a change of zoning from agricultural to residential. To make such a change, a hearing would be needed. The zoning commission hearing usually would involve concerned parties who want to tell the commission what they think of a proposed zoning change. The commissioners would listen to the testimony of various people, including land owners, developers, neighbors, "experts," and others. The commissioners then would make their decision.

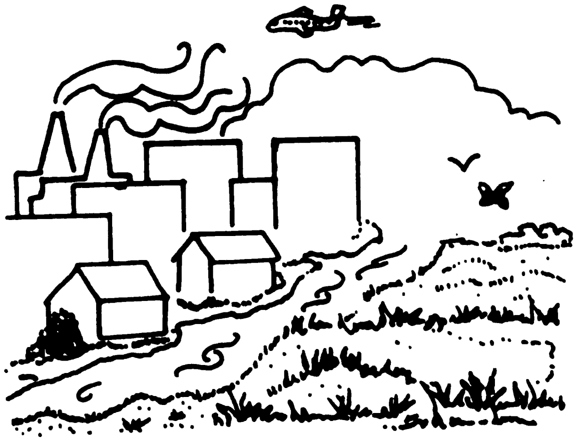
The commissioners would have to consider both the rights of individuals and what is best for the general community. Each individual, of course, has his or her own preferences and ideas about what is best. It is hoped that the commissioners would vote for what they think is best for the community as a whole.

In this activity, you will play the part of a resident of the fictitious community of Thoreau. Thoreau has a population of about 10,000 people. The economy is okay, but not thriving. The Bailey Appliance Company is the major employer for the community, currently employing 600 people. They want to expand their operations. This would provide about 200 new jobs. To do this, though, they would have to enlarge their plant and destroy Butterfly Meadow and some adjacent land. In addition, about 180 new homes would need to be built.

There are two related proposals before the zoning commission:

Proposal #1 would change the zoning on Butterfly Meadow from agricultural to industrial.

Proposal #2 would change the zoning of land owned by Tom Olson from agricultural to residential zoning.



APPENDIX B, XX

Name ______________________ Class __________ Date __________

4.3 What Price Open Space? Questions

1. What are some factors that zoning commissioners need to take into account when considering a zoning change?

2. If you were a zoning commissioner in this hearing, how would you have voted? What factor(s) were most important in this decision?

3. List some things that you would do if you wanted to make a presentation to a zoning or planning commission.

4. Discuss the statement that "If we don't develop the land now, we can change our mind later. If we develop it now, we can't change our mind later."

5. Find out when and where your local planning or zoning commission meet.

4.3 continued

Maria or Miguel Martinez, MERCHANT (CHAIRPERSON OF THE ZONING COMMISSION)

You own a store that sells several brands of home appliances, including Bailey's. Business has not been very good lately, and you have not been able to hire any help at the store. As a result, you have little time to enjoy the out of doors.

Megan or Martin Bailey, VICE PRESIDENT OF THE BAILEY APPLIANCE COMPANY (ZONING COMMISSION MEMBER)

You have lived in the community all your life. You are 45 years old and have two children, ages 13 and 16. Your company is the major employer for the community, and you want to expand your operations. Since you have a vested interest in the proposed zoning change, you will have to abstain from voting.

Joan or John Elder, REALTOR (ZONING COMMISSION MEMBER)

You have lived in the community for 10 years and are very involved in community affairs. Your company is not developing the property in question, but you generally favor development. At the same time, you are concerned about the quality of life. You like the small-town atmosphere of Thoreau.

Bonnie or Bob Hubbs, FARMER (ZONING COMMISSION MEMBER)

Your farm is doing well and you have been considering expanding. The parcel under consideration is one of several that you have been considering buying, but you have not yet talked with the current owner. You enjoy working outdoors and try to use environmentally sound farming techniques.

Mike or Madi Sherron, LOCAL ACTIVIST (ZONING COMMISSION MEMBER)

You have been elected by the liberal faction of the community and almost always vote against development. Like your constituency, you moved to Thoreau because it was a small town and you want it to stay that way. You are also concerned about the impact of 180 new homes on the local sewer system.

Julie or James Stevens, LOCAL LAND OWNER

Your mother owned the property in question until she died six months ago. You live in a city about 200 miles away and would like to sell the property.

Helen or Hal Peterson, LOCAL RESIDENT AND HUNTER

You are an avid outdoorsperson and hunter. You have hunted on the property in question all your life, and you enjoy hunting there with your two teenaged children.

4.3 continued

Louise or Lee Chin, DEVELOPER

Your company is the major builder in the Thoreau area. You have a reputation for building good homes at reasonable prices and for attempting to minimize environmental damage done by your developments. You are interested in purchasing the property and building the homes and expansion for Bailey Appliance Company. You would like to build homes that are affordable for working-class people.

Renee or Ron Stone, BANKER (PRESIDENT OF THE CHAMBER OF COMMERCE)

Your bank is the major real estate financier for the community, and you are interested in making new home loans. You live in a nice neighborhood that overlooks Butterfly Meadow and enjoy the view of the meadow and neighboring woods.

Alice or Alex Brown, LOCAL RESIDENT AND MEMBER OF THE COMMITTEE TO SAVE BUTTERFLY MEADOW

You moved to Thoreau because you wanted to raise your family in a small town, away from the city in which you were raised. You enjoy hiking and birdwatching in Butterfly Meadow and think that you once spotted an endangered species of bird called Wilson's Spotted Warbler there.

Cathy or Chris Nelson, LOCAL RESIDENT, RETIRED

You are 85 years old. For the last 15 years you have lived in a small cottage that the former owner of the property in question let you rent very cheaply in exchange for helping maintain the property and general caretaking. You have very little income and cannot afford to buy or rent in Thoreau. If you have to move, you will have to live with your son, who has a family and lives in New York City.

Fran or Frank Walkingtall, LOCAL RESIDENT

As the leader of the local Native American organization, you are very concerned about the Butterfly Meadow area. It was an important campsite and has several sites that were sacred to your ancestors.

"J.T." O'Neill, COLLEGE STUDENT

You were raised in the big city and have been attending a college in a town about 50 miles from Thoreau. You are engaged to marry someone who lives in Thoreau and hope to move there to teach school after you graduate.

APPENDIX C: AUDIO-VISUAL AIDS

APPENDIX C
AUDIO-VISUAL AIDS

The following audio-visual aids were shown to reinforce certain topics. I rated each one from one to five, with five being the best. The numerical rating is shown in parentheses following the title.

National Geographic's *Last Feast of the Crocodiles* (5) was shown to display the complexity of the food web on the African savanna. To satisfy the needs of one type of organism, it must overcome the danger of becoming the satisfied need of another. Drought conditions necessitate change in lifestyle if an organism is to survive; this special documents the struggle among the animals left in dying water pools after the 1991 drought there.

What They Say About Hunting... an in-depth look at the hunting controversy (4) is presented by the Council for Wildlife Conservation and Education. The video tries to slice its way through the emotional rhetoric and name-calling to arrive at some facts about hunting. The program analyzes the position statements of numerous conservation organizations, preservationist groups, humane societies, and individuals in an attempt to separate fact from opinion in the hunting debate. It explores the questions: Are hunters killing off our remaining wildlife, is hunting an acceptable activity in our modern society, and is there really a true contest between hunter and game? The video does not draw conclusions for its viewers.

Another short video put out by the Council for Wildlife Conservation and Education is *The Un-endangered Species: The success of wildlife management in North America* (3). This program explores the growth of wildlife management and examines its role in rescuing numerous species of America's wildlife from the brink of extinction to healthful and abundant numbers today. Some of the species covered include the wild turkey, elk, and trumpeter swan.

A favorite documentary of mine is National Geographic's *Great White Shark* (5). It displays the raw power that the great white shark has as a predator. However, the shark is still a social animal. Spectacular underwater photography shows the great white shark in its own domain, the marine ecosystem.

Keeping Nature in Balance (3) is a documentary that features seven award-winning cattlemen and the steps their families are taking to ensure the land is productive for this and future generations. You see how these families have incorporated sound conservation practices into their successful cattle businesses. It is produced by the National Cattlemen's Association and Beef Board.

APPENDIX C
AUDIO-VISUAL AIDS

Symbiosis (5) is just one video in The Trials of Life series produced by Time-Life. Exceptional photography and content illustrate several examples of mutualism and commensalism. Amazing combinations of organisms often work together and assist each other in unimaginable ways. Parasitism is also covered.

When discussing biomes, the video *Arctic--Life on the Edge* (5) fits in well. It shows the fragility of certain ecosystems like the tundra and the delicate balance that is easily interrupted. Organisms that call the arctic home must be highly adapted to survive. There is not much diversity. This film is a special documentary of the National Geographic Society.

Another presentation that displays a distant yet extremely important biome, is *Rainforest* (4), a National Geographic video. The tropical rain forests of the world are home to nearly one-half of the animal species on Earth. More than 100 inches of rainfall each year sustain this lush environment, where some of the most fascinating examples of natural adaptation can be found. It is an eloquent warning of the natural wonders we stand to lose on a world scale if human encroachment of the world's rain forests continues.

Wild Things: An Earth Day Special (4) is a neat way to raise awareness of our special "environmental holiday". This special includes segments on baby animal predators, migration, speed and locomotion, and how to save endangered species. It is fast-paced and enjoyable to students to watch. It is produced by KIDSNET.

APPENDIX D: *ENVIRONMENTAL SCIENCE* TESTS

I....Pre-test
II...Unit One Test
III..Unit Two Test
IV...Unit Three Test
V....Unit Four Test
VI...Unit Five Quiz
VII..Final Exam

APPENDIX D, I
Pre-test

PRETEST for ENVIRONMENTAL SCIENCE

1. All of the parts of Earth that support life are collectively called: a. atmosphere b. biosphere c. habitats d. lifezone e. environment

2. How many control setups should environmental scientists include in one experiment? a. no more than two b. at least two c. only one d. enough to cover all variables e. all of the above

3. A large carnivore whose prey is widely dispersed needs:
a. a large territory b. a diverse community
c. to be cold-blooded d. to be a generalist species

4. An ecosystem with low biodiversity contains:
a. few communities b. few species c. small populations
d. a small geographic range

5. As a rule, mature ecosystems are characterized by:
a. large populations b. abundant producers
c. simple food webs d. high species diversity

6. Biological magnification involves increasing concentrations of: a. dissolved salts b. toxins
c. diverse species d. nesting birds e. producers

7. Bird species A lives in the top of a tree; bird species B lives in the middle of the same tree. They both feed on insects. Which of the following is true about these bird species? They: a. inhabit different niches b. inhabit different habitats c. have the same geographic range
d. compete for space in the tree

8. The size of the community living in an ecosystem is limited by all of the following <u>except</u> the:
a. number of predators b. ecosystem carrying capacity
c. species diversity d. size of the territory

9. Nodules on the roots of soybean plants contain nitrogen-producing bacteria. The nitrogen feeds the plants. The plants provide organic material for the bacteria. This relationship is an example of: a. parasitism
b. cooperation c. commensalism d. mutualism

10. The largest biome on Earth is: a. forest b. savanna
c. tundra d. desert e. marine

APPENDIX D, I

11. Which event would form conditions under which primary succession would occur? a. volcanic eruption
b. lightning storm c. fire d. human disturbance

12. Choose the statement that does not describe how fire benefits grasslands. Fire:
a. destroys dead plant roots. b. destroys dead grasses.
c. releases nutrients to soil. d. aids in seed germination.

13. A giraffe's long neck is an adaptation to what ecological factor in the savanna? a. seasonal rainfall
b. tree thorns and sharp leaves c. many predators
d. competition among herbivores

14. What characteristic is shared by both conifers and succulents, and serves the same purpose for both?
a. They have thorns for protection. b. They have wax-coated leaves to conserve water. c. Their seeds are contained in cones. d. They flower during periods of low rain.

15. Clear-cut rain forest is likely to never regenerate because: a. the soil is so poor in nutrients
b. so little sunlight reaches the ground c. the soil will become water-logged d. trees take so long to grow

16. In which part of a freshwater biome would scavenging organisms most likely live? a. benthic zone
b. brackish zone c. photic zone d. tidal zone

Use this information for questions #17-18. An eagle eats a snake which eats a mouse which eats certain seeds from plants.

17. Which is the prey? a. seeds b. producers
c. top-level consumer d. snake e. eagle

18. The ecological pyramid illustrates energy loss and population size. Based on the pyramid, which organism would be least abundant?
a. seed plants b. mouse c. snake d. eagle

19. Which is the largest? a. habitat b. species
c. community d. population e. ecosystem

20. The carrying capacity of an ecosystem is:
a. the amount of organisms it could support
b. the number of predators needed to keep certain population levels under control
c. the area needed to support a certain number of producers
d. the number of prey needed for a certain species to live in an area

APPENDIX D, I

NAME:

-----SHORT ANSWER--

21. Normally, ecosystems are stable. What do you call this state of balance? And, what are 2 things that can disrupt an ecosystem?

22. Imagine you went outside and took the body temperature of every lizard you found. Here are the results, all in degrees Fahrenheit.

75, 88, 67, 65, 82, 77, 76, 77, 73, 44

a-Is there a true normal lizard body temperature?

b-Is the 44° just a mistake that you should throw out?

c-What conclusion, if any, can you draw from this?

23. Leaves on trees lose water each day. This is called transpiration. If you put a Ziploc baggy over a leaf, the water which normally evaporates, is collected in the bag. By weighing each baggy before it's put on a leaf, you can calculate the amount of water lost by weighing it after it's been on a leaf for a day. Pretend you put 4 baggies on 4 leaves which are in the shade, and 4 baggies on 4 leaves which are in the sunshine. All of the baggies weighed 5.5 grams before you put them on the leaves. Results: <u>Shaded leaves:</u> 6.5, 5.8, 5.9, 6.2

<u>Sunny leaves:</u> 6.7, 7.0, 7.1, 6.9

a-What was the objective or purpose of this lab? (2)

b-What can you conclude? (2)

24. When there are no limits on a population, its growth gets out of control. What do you call this kind of growth?

25. List an alien species.

APPENDIX D, II
Unit One Test

Environmental Science--Test 1 Name______________________

Multiple Choice--Use **CAPITAL** letters please!

_____1. When combined, all parts of the Earth that support life are called the: A) atmosphere B) biosphere C) lithosphere D) hydrosphere E) range of tolerance

_____2. Science can best be described as: A) a difficult process B) an information gathering process C) a kind of logic D) based on absolute facts E) unreliable

_____3. Environmental science is the study of: A) toxins in the air B) the history of Earth C) everything that surrounds an organism D) the living things that affect an organism E) the outdoors

_____4. Which of the following would not be part of an organism's environment? A) available water B) its ancestry C) vegetation D) air quality

_____5. What is the most important requirement for all living things? A) water B) vitamins C) light D) carbon dioxide E) sleep

_____6. Animals need territory to provide them with food, water, and: A) trees B) competitors C) shelter D) places for scent markings

_____7. Some plant seeds live through cold winters but do not sprout until spring. In winter these seeds are: A) dead B) multiplying C) hibernating D) dormant E) germinating

_____8. Painted turtles are cold-blooded animals that often sit on logs and bask in the sun. Why might they do this? A) to decrease their body temperature B) to raise their body temperature C) to evaporate water D) to remain dormant E) all of the above

_____9. All of the following are characteristics of hibernation or becoming dormant ***except***: A) slow breathing B) low body temperature C) high energy requirements D) slow heart rate

_____10. Members of a given species: A) can produce fertile offspring B) share resources with each other C) live in the same territory D) always live in the same population

APPENDIX D, II

_____11. Food, shelter, proper temperature, and other resources are provided by an organisms: A) habitat B) geographic range C) species D) climate E) population

_____12. The cheetahs in Kenya and the cheetahs in Tanzania make up separate: A) territories B) populations C) communities D) species E) ecosystems

_____13. Abiotic components of a community include all of the following ***except***: A) weather B) rock formations C) soil D) plants

_____14. How is the biodiversity of an ecosystem measured? A) by the number of species it contains B) by the number of individuals it contains C) by the size of the community D) by the number of habitats found in it

_____15. All living things can be called: A) mobile B) consumers C) organisms D) species E) bodies

_____16. People are slow to enact laws to protect old-growth forests because: A) old trees cause fires B) there are already too many trees on Earth C) some people will lose their jobs D) the forest is an unstable environment

_____17. Which is a biotic factor of an organism's environment? A) sunlight B) mates C) shelter D) precipitation E) wind

For questions #18-20, use this scenario.

In order to find out what the requirements are to germinate (sprout) seeds, take two Petri dishes and put paper towel in each. Moisten the paper towel in one dish and label this dish "A". Label the other dish "B". Place 3 radish seeds on the paper towel in each dish and observe for 3 days to see if they germinate.

_____18. Which is the control? A) A B) B C) there is no control

_____19. Which is <u>not</u> a constant? A) using the same size Petri dishes B) keeping each in the same amount of light C) wetting the paper towel in dish "A" D) storing both dishes in the same temperature

_____20. What is the best hypothesis you could pick prior to performing this experiment?
A) Paper towel is necessary to germinate radish seeds
B) Light will enhance the chances of germination
C) Water is needed for seeds to germinate
D) Dry soil will work as well as wet to cause seeds to sprout

APPENDIX D, II

_____21. Which type of organism is likely to suffer the effects of biological magnification most? A) a decomposer B) a secondary consumer C) a primary consumer D) a tertiary (3rd-level) consumer

_____22. Which is the second step of the scientific method? A) analyze B) hypothesis C) observe/state problem D) theory E) experiment

_____23. All of the abiotic and biotic factors that surround you make up your: A) species B) community C) territory D) environment E) ecology

_____24. What happens to toxic substances put into Lake Michigan? A) They wash out of the lake in a few years. B) The lake has a turnover rate of 100 years. C) The toxic substances disappear since the plants take them in. D) They will never move out of the lake.

_____25. The part of the lab report that includes just the data is the: A) conclusion B) procedure C) results D) procedure E) analysis

_____26. The part of the lab report that includes your interpretation of the facts and whether or not you proved your hypothesis is: A) conclusion B) procedure C) results D) procedure E) analysis

_____27. A good example of what an <u>ecologist</u> studies would be:
A) how the water cycle works and rain is made
B) how the fungus and a slug interact of a dead log
C) the number of bees in a hive
D) the weather patterns over Texas
E) all the non-living and living things surrounding you

_____28. Together the cactus, lizard, and jackrabbit populations make up the: A) environment B) species C) habitat D) community E) ecosystem

_____29. What is **<u>NOT</u>** a need of every living organism? A) food B) air C) living space D) climate E) water

<u>Short Answer</u>

30. Several years ago, scientists from Utah announced that they had achieved "cold-fusion" production of energy by fusing atoms at low temperatures. When other scientists tried to duplicate their experiments, cold fusion was not achieved. Why was "cold fusion" finally rejected by the scientific community? (2)

APPENDIX D, II

31. A healthy ecosystem includes a wide biodiversity: it has a full and rich mixture of species living in it. Yet in nature, there are far more species of organisms living in tropical rain forests than live in the Arctic. Are rain forests healthier ecosystems than the Arctic? Explain your answer. (3)

32. Could animal life exist on Earth without plants? Explain why or why not. (3)

33. One goal for the Great Lakes is "zero discharge". Explain this concept. (2)

34. To see if her pear tree would produce better quality fruit, Shawn decided to spray her tree. At the end of the pear season, she concluded that spraying did not help. Is this a valid experiment? Explain your answer. (3)

35. You are warm-blooded. What does this mean? (2)

36. What is your specific habitat? (2)

37. List 6 biotic factors of your environment. (3)

38. Why are humans particularly vulnerable to toxic pollutants in the environment? (Why are we more likely to die from pollutants than a snake?) (3)

<u>EXTRA CREDIT</u> I. Oxygen make up what % of the air?___________
II. The last section of a lab report is the ___________________

APPENDIX D, III
Unit Two Test

Unit 2 Test--Ecosystem Interactions & Balance

Multiple Choice--Put your answers on the Scantron sheet.

1. An organism's niche is: A) its size B) where it hides C) its role in the ecosystem D) how it avoids predators

2. An herbivore might eat all of the following *except*: A) algae B) leaves C) ferns D) ants E) broccoli

3. Which of the following animals is <u>not</u> a carnivore? A) deer B) dog C) cheetah D) tiger E) bear

4. Raccoons will eat almost anything. They are most accurately called: A) herbivores B) omnivores C) carnivores D) producers E) decomposers

5. Condors are related to vultures and feed on carrion, or dead animals. Condors' role in the food web is as: A) decomposers B) primary consumers C) autotrophs D) scavengers E) producers

6. You are a secondary consumer when you consume a: A) candy bar B) chicken salad C) glass of orange juice D) piece of bread E) cereal

7. To be a tertiary consumer, you'd have to eat: A) hamburger B) lamb C) tuna fish D) peanuts E) cereal

8. Leaf litter on the forest floor becomes new soil through the actions of: A) decomposers B) herbivores C) tree roots D) scavengers E) water

9. From where do autotrophs get the energy that produces their food? A) fungi B) the sun C) plants D) a lower trophic level

10. Heterotrophs can be all of the following *except*: A) producers B) scavengers C) primary consumers D) secondary consumers

11. Food web stability is most dependent on: A) the abundance of primary consumers B) the presence of decomposers C) the number of connections among species D) the severity of the ecosystem's climate

APPENDIX D, III

12. In the Antarctic, as baleen whale numbers increase you would expect seals to: A) decrease in numbers B) maintain the same population C) increase in numbers D) move to another territory

13. Which word describes the food web in a mature ecosystem?
A) simple B) unstable C) complex D) uncompetitive

14. Which type of organism is likely to suffer the effects of biological magnification most? A) a decomposer
B) a secondary consumer C) a primary consumer
D) a tertiary (3rd-level) consumer

15. Which organisms represent the most biomass in an ecosystem?
A) producers B) secondary predators
C) scavengers D) herbivores

16. In one day, a zebra eats 10 kg of grass. A lion kills and eats the zebra. About how much of the energy contained in this <u>grass</u> is usable by the lion?
A) 10 kg B) 5 kg C) 1 kg D) 0.1 kg

17. The ecological pyramid illustrates energy loss within an ecosystem. However, in doing this it also depicts population size within an ecosystem. Based on the pyramid, which type of organism would be <u>least</u> abundant in any ecosystem?
A) tertiary (3rd-level) consumers B) secondary consumers
C) primary consumers D) producers

18. Legumes enrich soil by adding nitrogen to it through their:
A) leaves B) chloroplasts C) nitrates D) root nodules

19. Which word does <u>not</u> belong when discussing the water cycle? A) ecosystem B) precipitation
C) condensation D) runoff E) evaporation

20. Which word is <u>not</u> involved in the nitrogen cycle?
A) animals B) bacteria C) transpiration D) decomposers
E) waste/excretion

21. Competition occurs between species when:
A) they fight for mates
B) a new niche becomes available
C) they share the same niche
D) their niche is destroyed

22. Which of the following is <u>not</u> a predator?
A) squirrel B) spider C) mountain lion D) hyena

APPENDIX D, III

23. What effect does a (keystone) predator have on its habitat? A) It destroys the habitat.
B) It increases plant populations.
C) It increases habitat diversity.
D) It kills all herbivores.

24. Populations respond, over time, to changing environments through the process of: A) niche B) predation
C) competition D) ecology E) evolution

25. What might happen if species A moved into a niche occupied by species B? a. The food resource would be shared.
b. Both species would eventually starve.
c. One species would be forced to leave.
d. Both species would fight to the death. e. Nothing.

26. In a balanced ecosystem, the carrying capacity for a given species should be: a. increasing b. decreasing
c. fluctuating d. stable

27. When lemming populations decline, populations of Arctic foxes also decrease. The limiting factor on the population of Arctic foxes is: a. abiotic b. exponential
c. density-dependent d. density-independent

28. Ecosystems always want to maintain a state of balance, which is: a. evolution b. niche diversity
c. equilibrium d. succession

29. Which of the following is a density-independent factor limiting population growth? a. competition for resources
b. living space c. food supply d. volcanic eruption
e. number of predators

30. As human populations grow, all of the following will likely result <u>except</u>: a. wars over resources
b. extinction of other species c. expansion of agriculture
d. expansion of open space & wilderness

31. Lions hunt wildebeests. Therefore, wildebeests are:
a. predators b. prey c. vegetarians d. numerous

32. The size of the host population controls:
a. the size of the prey population
b. the size of the parasite population
c. important bodily functions
d. the geographic range of parasites

33. Parasitism is an example of: a. coevolution
b. ecosystem balance c. predation d. harmful symbiosis

APPENDIX D, III

34. A commensal relationship (commensalism) is one in which:
a. both organisms are harmed
b. neither organism is helped or harmed
c. one organism benefits and the other is not harmed
d. one organism is harmed

35. The first organisms to colonize a newly formed <u>lifeless</u> habitat are part of: a. mature communities b. primary succession c. a new species d. a shoreline ecosystem

36. Lichens are important to an ecosystem because they:
a. help form soil b. are unstable
c. prevent trees from growing d. replace older communities

37. A mature, stable, and diverse ecosystem is called:
a. a habitat b. a primary forest c. successful
d. a climax community

38. Secondary succession occurs after a disturbance in an ecosystem that does not destroy: a. species diversity
b. soil c. fire-resistant plants d. water sources

39. Through aquatic succession, a clear lake may eventually become: a. an aquifer b. a meadow
c. barren rock d. an ocean

40. Stability returns to disrupted ecosystems because:
a. organisms remain stable
b. conditions return to normal
c. ecosystem disruptions are never catastrophic
d. ecosystems adjust to new conditions

41. Different types of ecosystems--depending on the factors of rainfall, temperature, and organisms present--are categorized as different types of: a. successional stages
b. biomes c. niches d. habitats

42. Seventy-five percent of Earth's biomass is contained in:
a. the oceans b. biomes c. grasslands d. forests

43. The biome with the greatest species diversity is the:
a. rain forest b. tundra c. deciduous forest
d. savanna

44. Which biome receives the least amount of rainfall?
a. coniferous forest b. steppe c. savanna d. tundra

45. A tapeworm live off the nutrients in an animal's digestive tract. A tapeworm is, therefore, a(n): a. producer
b. host c. omnivore d. parasite e. barnacle on a whale

APPENDIX D, III

46. Elephants and rhinos tolerate the small birds that ride their backs and eat insects on their skin. The relationship between the birds and elephants is an example of:
a. commensalism b.mutualism c. parasitism
d.coevolution e. convergent evolution

47. Two species of clover were planted in the same patch of garden. In time, one species disappeared from the patch. This is probably the result of:
a. human disturbance b. niche overlap
c. habitat destruction d. competitive exclusion

48. Koala bears can eat only certain kinds of Australian eucalyptus leaves. Koalas are, therefore, considered to be: a. underfed b. a new species
c. a specialized species d. (keystone) predators

49. The carrying capacity for a species in an ecosystem is primarily determined by:
a. a boom-and-bust curve b. that species' fertility
c. the number of predators d. the ecosystem's resources

50. Organisms experience which of the following as a result of growing populations? a. enrichment
b. increased competition c. maturation d. stability

**You are done with the Scantron portion. Make sure you have marked on your Scantron sheet whether you have test version A or B.

**You may write on the remaining portion of the test.

APPENDIX D, III

UNIT 2 TEST
Written portion

Name____________________
Date____________________

1. Use the word "increase" or "decrease" to complete each statement about predator/prey relationships.

___________________a. An abundance of vegetation causes an herbivore population to ___.

___________________b. More prey soon results in a(n) ___ in the predator population.

___________________c. Greater predation leads to a(n) ___ in the prey population.

___________________d. With fewer predators, the prey population will eventually ___.

2. Could animal life exist on Earth without plants? Explain why or why not. (3)

3. At which trophic level do humans exist? (2)

4. a. Is it possible for 2 species of spiders to live in the school even though they may both eat small insects and "critters"? (1)

b. How might these spiders' niches differ to allow them to avoid direct competition? (2)

5. List at least one *ecological* pro <u>and</u> con of hunting deer here in Michigan. (3)

6. What can you say about the fact that certain plants produce sweet nectar to attract bees that pollinate them? (2) (HINT: What has happened to them <u>over time</u>?)

APPENDIX D, III

7. Pretend there was a horrible nuclear explosion which completely removed all living organisms from an area. In fact it cleared everything away, so that only bare rock was exposed. Outline the stages of succession that would happen here. Describe which organisms would move in first and which would follow. (5)

8. What do you call any species that first moves into an area like that described above (in #7)? Hint: the general term, not a specific name (1)

9. Explain 2 ways humans can disrupt ecosystems, sometimes even unintentionally. (2)

10. Decide whether a specialized or generalized species would be more likely to go extinct. Explain your choice. (2)

11. How do you describe or calculate population density? (like with the water lettuce) (2)

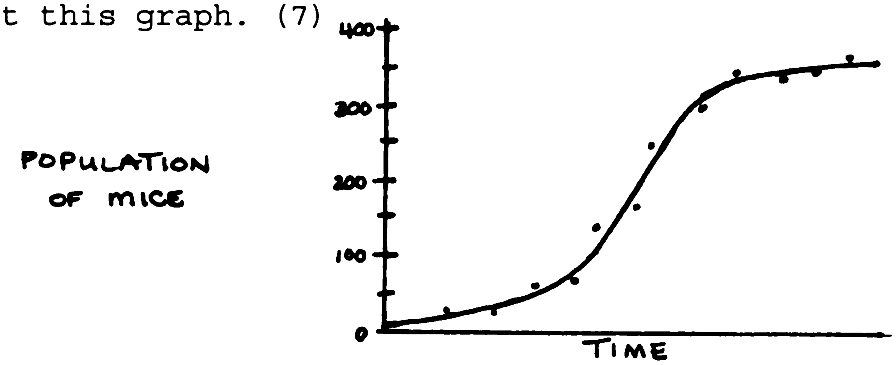
12. A cow must eat 25 kg of grain to produce 0.5 kg of meat. Explain the implications of this for feeding the growing human population. (3)

13. What would happen to ecosystems and organisms if scavengers and/or decomposers suddenly disappeared? (2)

APPENDIX D, III

14. It is hard to convince people of the need to protect the more unpopular species of endangered organisms such as insects, snakes, or even rare plants. Describe how the extinction of one organism can affect an ecosystem. (3)

15. Interpret this graph. (7)



a. What is the approximate carrying capacity?

b. What could you say about the birth and death rates in the middle of the graph?

...near the end of the graph?

c. Are there limiting factors present in this ecosystem? Explain.

d. How would this graph be different if this species had some form of birth control?

Extra Credit--Max +5

__________________What is the <u>actual</u> role of an organism in an ecosystem?

__________________What 2 organisms make up a lichen?

__________________What type of relationship exists between the two organisms that make up a lichen?

__________________When two different organisms develop similar features--like a bat & a bird--over time, what is it called?

__________________What word means land?

Explain whether or not the nitrogen cycle could survive without plants.

APPENDIX D, IV
Unit Three Test

Unit 3--Environmental Science test--Scantron portion

1. Minerals move downward through soils in a process called:
a. desertification b. mineralization c. leaching
d. decomposition

2. Few plants can survive in deserts because:
a. little leaching occurs b. there are many herbivores
c. the sun is too hot d. the climate is too dry

3. An important part of topsoil is:
a. decayed organic matter b. plant roots
c. permafrost d. loam

4. The compacted desert pavement prevents:
a. plants from absorbing water b. the ground from absorbing rain c. animals from burrowing
d. the washing away of topsoil

5. What causes temperature extremes in the desert?
a. nearness to the equator b. nearby mountain ranges
c. lack of moisture in the air d. lack of groundcover plants

6. Plants that store water in their tissues are called:
a. cacti b. succulents c. aloes d. sagebrush

7. Being nocturnal is an adaptation that helps desert animals survive because they: a. avoid the intense daytime heat
b. are protected in their burrows at night c. avoid the intense nighttime cold d. avoid nighttime predators

8. All of the following result from overgrazing in semiarid regions **except**: a. topsoil erosion b. reduced rainfall c. soil compaction d. regeneration of grasses

9. One reason tundra plants are small and tend to grow close to the ground is because:
a. animals eat them before they can grow
b. permafrost prevents penetration of deep roots
c. water is easier to obtain at ground level
d. mosquitoes and black flies destroy taller plants

10. How has air pollution contributed to the decline in caribou populations? It has: a. warmed the tundra climate
b. decreased the heat-conserving ability of their fur
c. caused them to alter their migration routes
d. destroyed some of the lichens they feed on

APPENDIX D, IV

11. Grasslands occur between deserts and: a. mountains
b. forests c. oceans d. lakes

12. Destruction of vegetation by human activity could devastate the tundra because:
a. the pavement would be exposed b. plant diversity is low
c. plants grow back slowly d. the plants are so dwarfed

13. Which of the following statements describes the amount of rainfall in grasslands?
a. less than deserts, more than tundras
b. more than deserts, more than forests
c. more than deserts, less than forests
d. less than deserts, less than forests

14. Which of the following is a characteristic of the desert-grassland boundary? It is: a. unstable b. well-defined
c. stable and unchanging d. similar to tall-grass prairie

15. Grasses can withstand the fires common to grasslands because grasses: a. store water in their leaves
b. have extensive root systems
c. grow thickly together
d. are full of moisture

16. Which of the following is **not** a way the grasslands benefit from fires? Fires: a. aid grass-seed germination
b. burn away dead vegetation
c. release nutrients to the soil
d. make room for new trees

17. In grassland regions, rainy seasons and drought seasons determine:
a. the spread of fires b. the location of streams
c. temperature d. behavior of resident organisms

18. Grasslands that have rolling hills and sod-forming grasses are known as: a. prairies b. bunchgrasses
c. savannas d. steppes

19. Sod-forming grasses are characterized by their: a. height
b. ability to grow in poor soil c. uniformity
d. matted roots

20. Native grasses in many of the world's grasslands have been replaced with: a. cereal grains
b. sod-forming grasses c. humus d. bunchgrass

21. The seeds of many grassland plants are distributed by:
a. rain b. migration c. runners d. winds e. animals

APPENDIX D, IV

22. Savannas typically have short rainy seasons followed by:
a. periods of drought b. migrations of animals
c. the formation of marshes d. grass fires

23. Rainfall on savannas is best described as: a. plentiful
b. short-lived and intense c. unreliable d. monthly

24. Horizontal stems below the ground are called:
a. compost b. spines c. roots d. runners

25. The horizontal stems of some savanna plants are used for:
a. reproduction b. anchorage c. holding water
d. holding nutrients

26. Sharp leaves and thorns help savanna plants by:
a. storing water b. discouraging grazers
c. attracting sunlight d. growing fast

27. A vertical feeding pattern helps savanna herbivores:
a. avoid competition for food b. find water
c. avoid predators d. limit their diets

29. The deciduous forest layer that gets the least sunlight is the: a. understory layer b. shrub layer
c. canopy d. forest floor

30. Coniferous forests are generally located:
a. at high temperatures b. in the Northern Hemisphere
c. near deserts d. where summers are dry

31. Which of the following statements is **not** true of coniferous forests?
a. Rainfall is scarce. b. Seasonal temperatures vary widely.
c. Summers are generally short. d. Winters are long and cold.

32. Precipitation in deciduous forests is best described as:
a. seasonal b. rare c. occurring mainly in spring
d. occurring throughout the year

33. Which abiotic factor causes organic matter to decay more rapidly in deciduous forests than in coniferous forests?
a. colder and dryer winters b. warmer and wetter summers c. more topsoil d. higher canopy

34. Animals might not return to a replanted deciduous forest because of its: a. rapid tree growth b. empty niches
c. lack of plant diversity d. greater openness

35. The biome that is the most productive and diverse on Earth is the: a. rain forest b. coniferous forest
c. deciduous forest d. desert e. Pacific Northwest

APPENDIX D, IV

36. In rain forests, habitats are classified:
a. according to different trees b. vertically
c. by water level d. in the canopy

37. Which of the following is **not** a reason why rain forests are cleared?
a. to find new species b. to make grazing land
c. to export wood d. to make farmland

38. In deserts, limited leaching results in:
a. mineral-rich soil b. mineral-poor soil
c. little rainfall d. abundant rainfall

39. Most desert plants survive the harsh climate because they are able to: a. grow spines b. store water
c. limit photosynthesis d. grow deep roots

40. Flowering tundra plants must bloom and set seed quickly because:
a. otherwise they are eaten
b. the tundra is very windy
c. they grow close to the ground
d. the summers are very short

41. A biotic factor that mixes and aerates grassland soil is:
a. sod formation b. fire
c. clumping of grasses d. burrowing animals

42. Prairies and steppes grow rich crops of grain because:
a. the soil is very fertile b. the soil is very dense
c. grain is a grass d. grain is wind-pollinated

43. Which of the following statements does **not** describe a way that sod benefits the prairie ecosystem? It:
a. retains soil moisture
b. spreads runners
c. prevents soil from blowing away
d. prevents soil from washing away

44. Which of the following is **not** a characteristic of a conifer?
a. It has needle-shaped leaves.
b. Its triangular shape sheds snow.
c. It drops its leaves in the fall.
d. Its seeds are contained in cones.

45. In winter, the fur of snowshoe hares living in coniferous forests turns white. This helps the hare to:
a. burrow beneath the snow
b. protect itself from predators
c. stay warm
d. find vegetation under the snow

APPENDIX D, IV

46. The predominant forest biome in the temperate zone is the:
a. coniferous forest b. old-growth forest
c. rain forest d. deciduous forest

47. The layers of a deciduous forest enhance its:
a. species diversity b. groundcover
c. absorption of rain d. succession

48. Leaf-eating animals of the rain forest would most likely live: a. on the ground b. on buttresses
c. in the canopy d. near shrubs

49. The vast species diversity in rain forests indicates that these forests: a. are very hot b. have rich soil
c. lack predators d. have many niches e. should be cut down

50. Deforestation of rain forests will likely lead to:
a. less cutting of temperate forests
b. extensive species extinction
c. a wetter world climate
d. a less vertical ecosystem

APPENDIX D, IV

ENVIRONMENTAL SCIENCE--Biomes Name________________________
Unit 3--Written portion Date___________

1. The state of Montana is landlocked in the north-central of the United States. New Jersey is on the Atlantic Ocean coast. Which state would you expect to have greater variations in temperature? Why? (3)

2. The roots of some desert plants contain a substance that prevents other plants from taking root near them. Explain why this is important for a desert plant. (2)

3. Ranchers who graze their livestock on semiarid government-owned land pay about one-fifth as much as ranchers who graze their animals on private land. What can you infer about the government's grazing-fee policy and desertification of these areas? (4)

4. How does the desert pavement and the tundra permafrost affect their respective biomes, particularly the plants? (3)

5. Imagine that there has been an oil spill on the tundra.
   a. Where would the oil go? (1)

   b. About how long would the oil remain in the ecosystem? (1)

APPENDIX D, IV

6. Draw an imaginary animal that is well-adapted to living in the sometimes extreme conditions of the desert. Label at least two features of this animal and explain how they help it survive in the desert. (4) (The artwork is not the important part!)

7. Why is there so much animal diversity in the rain forest? There are two main reasons. (4)

8. Explain why savanna plants grow quickly. (2)

9. Why do you think giraffes have such long necks? (2)

10. Reforestation by lumber companies nearly always takes the form of "tree farms" replanting a clear-cut area with only one species of commercially valuable timber. Compare the biotic components of tree farms of forests. Can tree farms function as ecosystems? Why or why not? (4)

APPENDIX D, IV

11. Number each of the following from 1 to 4 according to its vertical position in a deciduous forest, with 4 being closest to the ground. (2)

understory_____ floor_____

canopy_____ shrubs_____

12. Very often, landslides and mudslides follow clear-cutting of old-growth mountain forests. Explain why this occurs. What can you infer about the role of trees regarding the soil of mountainous forests? (3)

EXTRA CREDIT

What event in 1988 caused the let-it-burn policy to come under debate?

What adaptation do some rain forest leaves have to deal with the excessive moisture precipitation?____________________

Those graphs that displayed both temperature and precipitation in each month of the year
for the different biomes are____________________

APPENDIX D, V
Unit Four Test

ENV-SCI UNIT TEST 4
Scantron portion

1. What biome covers the most area of our planet? A) tundra B) rain forest C) marine D) prairie E) desert

2. Aquatic biomes are characterized by:
A) their depth B) their location
C) amount of rainfall D) amount of dissolved oxygen

3. Salinity refers to: A) amount of dissolved salts
B) amount of dissolved oxygen C) density
D) temperature E) the plants

4. The mud you feel between your toes as you wade into Half Moon Lake is part of the lake's: A) plant life
B) benthic zone C) chemical zone
D) organisms E) intertidal zone

5. Aquatic plants can live in the benthic zone of shallow lakes because:
A) they live on decaying organisms
B) they cannot tolerate salt water
C) sunlight reaches the bottom
D) the bottom is always warm
E) kids swim near them and bring them oxygen

6. The area of shoreline that is alternately exposed and submerged is the: A) benthic zone B) neritic zone
C) oceanic zone D) continental shelf E) intertidal zone

7. The largest zone of the ocean is the:
A) benthic zone B) neritic zone C) oceanic zone
D) continental shelf E) intertidal zone

8. Which of the following is **not** true of the open ocean?
A) It has a rich benthic zone. B) It lacks a photic zone.
C) It is rich in plankton. D) It is extremely deep.

9. Which is the most productive ecosystem listed?
A) open ocean B) farmland C) coral reefs
D) grassland E) estuaries

10. The shallow border area that is underwater next to every major land mass is called the: A) shore B) abyssal plain
C) continental shelf D) estuary E) aphotic zone

APPENDIX D, V

11. Which of the following zones is most productive?
A) oceanic zone B) continental shelf C) neritic zone
D) intertidal zone E) abyssal plain

12. Coral reefs are composed of: A) limestone
B) animal skeletons C) eroded rock
D) jellyfish & anemones E) kelp & seaweed

13. Which is **not** an abiotic factor of water? A) temperature
B) CO_2 C) hardness D) plankton E) iron

14. Which type of water would have the highest DO (dissolved oxygen) level? A) fast moving, mountain stream B) lake
C) ocean D) large, slow river E) swamp

15. Nekton include: A) turtles B) benthic animals
C) algae D) plankton E) ocean plants

16. The final section of a lab report should always be:
A) results B) hypothesis C) conclusion D) materials
E) procedure

17. Phytoplankton (or plankton in general) are: A) consumers
B) scavengers C) producers D) decomposers

18. The neritic zone is the region between the:
A) continent and shore B) continental shelf & water surface
C) ocean bottom & photic zone D) high and low tide levels
E) continental slope & abyssal plain

19. The proper order for the sections (that are listed) of a lab report is:
A) Problem, Hypothesis, Materials, Procedure, Results
B) Materials, Procedure, Results, Conclusion, Hypothesis
C) Procedure, Problem, Conclusion, Results
D) Problem, Hypothesis, Results, Conclusion, Materials

20. What should be in the procedure of a lab report? A) data
B) an educated guess C) step by step directions
D) reasons for errors E) equipment to be used

APPENDIX D, V

ENV-SCI unit test 4 **NAME**____________________
Short Answer portion HOUR_____ DATE________

1. An estuary is a place where ocean water meets river water. What kind of water would you expect to find in an estuary? WHY? (2)

2. What connection can you make between the amount of dissolved oxygen (DO) in a body of water and the <u>number and diversity</u> of organisms that live within it? Give reasons and/or examples for your answer. (3)

3. The ozone layer over Antarctica is being destroyed. This has led to an increase in ultraviolet (UV) radiation reaching that part of Earth. Scientists have learned that the increased UV radiation is killing the plankton in the Antarctic seas. Predict what kind of effect this might have on the food web. (2)

4. Infer one reason why wetland waters, like swamps, contain very little dissolved oxygen (DO). (1)

5. Compare the oceanic zone to the desert. What factors contribute to the degree of species diversity in each? (2)

6. Countless species of marine animals lay their eggs in estuaries, which serve as great nurseries for the global oceans. What characteristic(s) of estuaries accounts for their role as breeding grounds? (2)

APPENDIX D, V

7. Some organisms of the intertidal zone, especially barnacles, have a lifestyle in which they attach themselves firmly--to a stationary object such as a rock, dock, etc. What condition(s) in the intertidal ecosystem makes immobility a useful adaptation for life in this habitat? (1)

8. What are 2 of the main hazards of trash incineration? (2)

9. What are 2 benefits of incineration? (2)

10. Pretend you were to do an experiment to see if water organisms prefer light. Write **2** hypotheses for this experiment that you could test in an aquarium using planaria (flatworms that swim). (2)

11. a. Now assume you are carrying out a similar experiment that involves temperature. You want to find out what temperature planaria prefer. You have an aquarium with a heating device at one end so there is a temperature gradient. In other words, it is cool at one end, moderate in the middle, and warm at the other end of the tank. Let's say you have 20 planaria. Why do you have so many? (2)

b. Where in the tank should you put the planaria? (1)

c. What things--at least 2--should be kept constant? (The factors that should <u>not</u> influence the planaria in making their decision.) (2)

d. Here are some pretend results. You did three trials.

	# hot	# moderate	#cold	
Trial 1	12	7	1	
Trial 2	10	6	4	
Trial 3	14	4	0	*two died

What can you conclude from your data? (2)

APPENDIX D, V

12. There was a vial with plain water in the toxicity lab with the germinating seeds. What purpose did it serve? (1)

13. Many of you had results of 1.3 to 1.8 squirrel(s) for the carrying capacity of two 10m x 10m sections of an oak forest. What does this mean? Does it account for other animals that might eat acorns? (3)

14. Many of you concluded that seeds are more likely to be eaten if they are closer to the parent tree. Why might one group have had an opposite result? (2)

15. <u>A NEW LEAF</u> QUESTIONS---Answer <u>**2**</u> of the following questions. **DO NOT ANSWER MORE.** (2)

a. What structures are being destroyed by the Invisible Dangers in Ch. 9? List two.

b. What company was the states #1 air polluter in 1988?

c. Who uses more pesticides per acre than farmers?

d. What did the book say about prepackaged microwave products like popcorn and pizza?

e. Michigan has the ________________ highest level of rainfall acidity in the United States.

f. Rain in Michigan has an average pH level of ______.

<u>EXTRA CREDIT</u>
a. Lake Baikal, in Russia, is the world's deepest lake, with a depth of 1,772 meters. About how deep, in meters, does Lake Baikal's aphotic zone reach?________________

b. A crayfish is what type of aquatic organism?_______________
c. Plankton that do NOT carry out photosynthesis are_____________________________________
d. How does temperature affect which fish live in a certain lake?

APPENDIX D, VI
Unit Five Quiz

Environmental Science Quiz NAME__________________
Unit 5

1. Ball Creek had a flow rate of 0.64 feet per second. Explain how we figured that out?

2. We tested many ______________ _______________ of water and soil. (the non-living aspects)

3. Explain how to use the plankton net and what it is used for?

4. Sometimes fertilizers and manure that is spread on fields

runs off and contributes to high levels of __________________ in creeks.

5. List four other tests (besides any listed above) performed on Ball Creek. (4)

6. For what reason(s) were the soil samples weighed before and after incubation.

7. List 2 key concerns or hazards of indoor air (how it can be polluted/dangerous). (2)

8. What triggers the chemical reaction in the blue, color-changing paper that we put under the glass/plastic?

APPENDIX D, VI

9. A paper bag weighs exactly 4 grams. Forty grams of wet soil was placed in the bag. After the soil dried in an oven overnight, the total weight of the bag and soil was 36g. Calculate how much of the soil was water. {Show work for partial credit.} (3)

10. What is the name of the instrument used to take the soil samples? (or, what is the name of the soil samples?)

11. List the 4 non-living aspects of soil you tested. (2)

12. If there was a small stream through East Kentwood with a flow rate of 0.3 feet/second, how would it compare to Ball Creek in terms of those tested items? Hypothesize as many reasons as you can why some levels may be different. (3)

13. Answer **ONE** of the following and circle which you are answering:

a. Why has the MI Air Pollution Act remained so weak for so long?

b. What has forced some waste producers to "economize" (dump illegally)?

EXTRA CREDIT: For what is asbestos still used?

The EPA estimates that MI ranks_______of the 50 states in toxic pollution.

The EPA stands for____.

APPENDIX D, VII
Final Exam

Welcome to ENVIRO SCI **final exam!** The first part is Scantron. The second part is short answer. Best of luck/skill to you.

1. All of the parts of Earth that support life are collectively called: a. atmosphere b. biosphere c. habitats d. lifezone e. environment

2. The hypothesis must be rejected when:
   a. another scientist tests it.
   b. it is too uncertain.
   c. it is only an educated guess.
   d. it is not supported by the data.

3. How many control setups should environmental scientists include in one experiment? a. no more than two b. at least two c. only one d. enough to cover all of the variables e. all of the above

4. Decisions made by the government about environmental policy must consider all of the following <u>except</u> the:
   a. interactions within the biosphere
   b. impact on local jobs
   c. number of researchers that study the policy
   d. impact on the environment

5. An environmental scientist who wanted to study the abiotic factors in an ecosystem would research all of the following <u>except</u>: a. available sunlight b. wind speed c. water salinity d. soil organisms e. temperature

6. Human activity has resulted in all of the following changes in the environment <u>except</u>: a. erosion b. plate tectonics c. desertification d. deforestation

7. Which of the following does not affect marine organisms?
   a. amount of dissolved oxygen b. water temperature
   c. local rainfall d. pollution from runoff

8. Sometimes on warm winter days bears leave their dens to look for food. Therefore, bears are not really hibernating, they are just: a. herbivorous b. omnivorous c. territorial d. dormant

9. A large carnivore whose prey is widely dispersed needs:
a. a large territory b. a diverse community
c. to be cold-blooded d. to be a generalist species

APPENDIX D, VII

10. An ecosystem with low biodiversity contains:
a. few communities b. few species
c. small populations d. a small geographic range

11. The extinction of a species means that:
a. an ecosystem has been destroyed.
b. it cannot tolerate human disturbance.
c. it is a specialist species.
d. its populations no longer exist.

12. Killing the vegetation in an ecosystem would destroy the entire ecosystem because:
a. most animals are herbivores
b. all life depends on producers
c. groundcover is essential to life
d. decomposers need dead plants

13. Regarding their place in the food chain, humans can be described as all of the following <u>except</u>:
a. heterotrophs b. omnivores
c. producers d. consumers

14. As a rule, mature ecosystems are characterized by:
a. large populations b. abundant producers
c. simple food webs d. high species diversity

15. Biological magnification involves increasing concentrations of: a. dissolved salts b. toxins
c. diverse species d. nesting birds e. producers

16. Bird species A lives in the top of a tree; bird species B lives in the middle of the same tree. They both feed on insects. Which of the following is true about these bird species? They:
a. inhabit different niches
b. inhabit different habitats
c. have the same geographic range
d. compete for space in the tree

17. The size of the community living in an ecosystem is limited by all of the following <u>except</u> the:
a. number of predators b. ecosystem carrying capacity
c. species diversity d. size of the territory

18. Predation is a factor that limits populations and is:
a. density-independent (does <u>not</u> depend on the population size) b. exponential c. abiotic
d. density-dependent (does depend on the population size)

APPENDIX D, VII

19. Which of the following is true of a host organism? It:
    a. is an example of convergent evolution
    b. has a commensal relationship with another organism
    c. is infected with parasites
    d. is not competitive or territorial

20. Which event would form conditions under which primary succession would occur? a. volcanic eruption
b. lightning storm c. fire d. human disturbance

21. Nodules on the roots of soybean plants contain nitrogen-producing bacteria. The nitrogen feeds the plants. The plants provide organic material for the bacteria. This relationship is an example of:
a. parasitism b. cooperation
c. commensalism d. mutualism

22. The largest biome on Earth is: a. forest b. savanna
c. tundra d. desert e. marine

23. How deep desert plant roots can grow is determined by:
a. soil b. rainfall c. permafrost
d. the pavement e. active zone

24. Many desert mammals have long ears filled with capillaries (tiny blood vessels). How does this adaptation help desert animals? It helps:
    a. nocturnal animals to absorb heat
    b. animals to cool their blood
    c. animals store water in their bodies
    d. nocturnal animals absorb moisture from dew

25. Erosion of topsoil in semiarid regions leads to:
a. increased leaching b. permafrost melting
c. spread of grasslands d. desertification

26. Which statement is <u>not</u> a reason why the tundra is prime nesting habitat for many migratory birds?
    a. There is little competition for food.
    b. Insects are abundant.
    c. There are few predators.
    d. There are lots of large plants to nest in.

27. What is one characteristic that both deserts and grasslands have in common?
    a. They are west of mountain ranges.
    b. Rainfall is the major limiting factor.
    c. They have no standing water.
    d. Their vegetation is shallow-rooted.

APPENDIX D, VII

28. Choose the statement that does <u>not</u> describe how fire benefits grasslands. Fire:
a. destroys dead plant roots. b. destroys dead grasses.
c. releases nutrients to soil. d. aids in seed germination.

29. Humus in grasslands is formed from: a. dead grass roots
b. living sod c. bunchgrasses d. lichens

30. The Dust Bowl in OK, TX, AK, was the result of all of the following <u>except</u>:
a. destruction of grass roots b. overgrazing
c. excessive irrigation d. drought

31. A giraffe's long neck is an adaptation to what ecological factor in the savanna?
a. seasonal rainfall b. tree thorns and sharp leaves
c. many predators d. competition among herbivores

32. What characteristic is shared by both conifers and succulents, and serves the same purpose for both?
a. They have thorns for protection.
b. They have wax-coated leaves to conserve water.
c. Their seeds are contained in cones.
d. They flower during periods of low rain.

33. In rain forests, where does the greatest diversity of organisms occur? a. leaf litter b. canopy
c. soil d. water

34. Which of the following sets of biotic factors is responsible for the formation of humus in deciduous forests?
a. leaf litter, herbivores, invertebrates
b. grass roots, decomposers, fungi
c. leaf litter, fungi, decomposers
d. plant roots, water, light

35. Which of the following is <u>not</u> true of rainforest trees? They:
a. have buttresses/supports since have shallow roots.
b. are evergreens with broad leaves.
c. are very diverse.
d. are very small.

36. Clear-cut rain forest is likely to never regenerate because:
a. the soil is so poor in nutrients
b. so little sunlight reaches the ground
c. the soil will become water-logged
d. trees take so long to grow

APPENDIX D, VII

37. In which part of a freshwater biome would scavenging organisms most likely live? a. benthic zone
b. brackish zone c. photic zone d. tidal zone

38. Together, the oceans of the world may be referred to as the world ocean because all oceans: a. are connected
b. are extensive c. are identical d. have similar zones

39. Where an organism lives is its: a. niche b. habitat
c. community d. population e. ecosystem

40. The first organism to move into a vacant area is a:
a. succession b. pioneer c. shrubs
d. oak trees e. conifers

Use this information for questions #41-44. An eagle eats a snake which eats a mouse which eats certain seeds from plants.

41. Which is the prey? a. seeds b. producers
c. top-level consumer d. snake e. eagle

42. This is an example of: a. a food web
b. an energy pyramid c. a food chain
d. biological magnification e. decomposers

43. Which organism is likely to suffer the effects of biological magnification the most? a. seed plants
b. mouse c. snake d. eagle

44. The ecological pyramid illustrates energy loss and population size. Based on the pyramid, which organism would be least abundant?
a. seed plants b. mouse c. snake d. eagle

45. One of the main producers of the oceanic zone is:
a. nekton b. seaweed c. plankton d. benthic plants
e. fish

46. Where fresh water rivers dump into the ocean is a(n):
a. salinity b. intertidal zone c. neritic zone
d. oceanic zone e. estuary

47. Which is the largest? a. habitat b. species
c. community d. population e. ecosystem

48. All of the biotic and abiotic factors that surround you make up your: a. ecology b. niche
c. community d. geographic range e. environment

APPENDIX D, VII

49. Which is not associated with grassland? a. runners
b. spotted owl debate c. savanna d. humus e. steppe

50. The carrying capacity of an ecosystem is:
a. the amount of organisms it could support
b. the number of prey needed for a certain species to live in an area
c. the number of predators needed to keep certain population levels under control
d. the area needed to support a certain number of producers

APPENDIX D, VII

FINAL EXAM--ENVIRO SCI NAME________________

Written portion DATE________________

1-a. Here is an experiment you can pretend you performed. You went to three locations--a drainage ditch, Ball Creek, and the Grand River--and tested various abiotic factors of the water. List 4 abiotic things you could have tested for (with the exception of water velocity). (4)

1-b. Now pretend you tested water velocity, or the flow rate of the water. Let's say the ditch had a flow rate of 6 inches per second, Ball Creek 4 in/sec, and the Grand River 10 in/sec. Which would you expect to have the highest dissolved oxygen level? Why? (2)

2-a. Male Siamese fighting fish do not like to be around other males. They will act aggressively toward each other, including puffing up their fins. The fish are colored bright red and blue. You want to see what it is that causes them to act aggressively--the red color, the blue color, or both. You have one fish in a small square tank. You test the fish by taking an index car with a big red fish sized spot on it and holding it up to the side of the tank. Record the results. Similarly, you test a blue and then a red and blue fish shaped picture. Write two hypotheses that you can test. (2)

2-b. Let's pretend these are your results. The fish attempted to fight the blue dot **and** the red and blue dot. The red did not seem to result in any specific response. Was this a valid or legitimate experiment? Why or why not? (2)

3. What do call any organism that eats both plants and animals? (1)

APPENDIX D, VII

4. Normally, ecosystems are stable. What do you call this state of balance? And, what are 2 things that can disrupt an ecosystem? (3)

5. What are 2 factors that limit a population's numbers? (2)

6. What is the difference between an animal's niche and its habitat. (2)

7. What are the main components of a lab report, listed in order. (5)

8. The neritic zone is the area of the ocean above the continental shelf. Why is this the most productive part of the ocean? (2)

9. Imagine you went outside and took the body temperature of every frog you found. Here are the results, all in degrees Fahrenheit. (3)

75, 88, 67, 65, 82, 77, 76, 77, 73, 44

a-Is there a true normal frog body temperature?

b-Is the 44° just a mistake that you should throw out?

c-What conclusion, if any, can you draw from this?

APPENDIX D, VII

10. Leaves on trees lose water each day. This is called transpiration. If you put a Ziploc baggy over a leaf, the water which normally evaporates, is collected in the bag. By weighing each baggy before it's put on a leaf, you can calculate the amount of water lost by weighing it after it's been on a leaf for a day. Pretend you put 4 baggies on 4 leaves which are in the shade, and 4 baggies on 4 leaves which are in the sunshine. All of the baggies weighed 5.5 grams before you put them on the leaves. Results: <u>Shaded leaves:</u> 6.5, 5.8, 5.9, 6.2

<u>Sunny leaves:</u> 6.7, 7.0, 7.1, 6.9

a-What was the objective or purpose of this lab? (2)

b-What can you conclude? (2)

11. What is brackish water? (1)

12. In which biome do we live? Be specific. (2)

13. Your choice. Do either a or b--NOT BOTH. (2)

a. When there are no limits on a population, its growth gets out of control. What do you call this kind of growth?

b. List an alien species.

<u>EXTRA CREDIT</u>

EX CR--Commensalism & mutualism are both types of __________

EX CR--Giraffes eating from the tops of trees is part of

the ____________________________ of the savanna.

EX CR--What is the most common pioneer species in primary succession?____________________