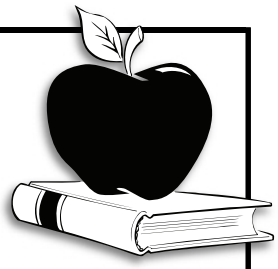
CLASS TIME: one class period

VOCABULARY: biological diversity (or biodiversity), conservation, preservation

MATERIALS: old, junked radios, telephones, clocks, toasters and other such equipment; tools to disassemble them, such as screwdrivers, pliers, etc.

NEXT GENERATION SCIENCE STANDARDS: MS-ESS3-4

TEACHER'S GUIDE



ACTIVITY

Intelligent Tinkering

Flower in the crannied wall,
I pluck you out of the crannies,
I hold you here, root and all, in my hand,
Little flower—but if I could understand
What you are, root and all, and all in all,
I should know what God and man is.

— Alfred, Lord Tennyson

OVERVIEW

By removing parts of a machine used to model an ecosystem, students learn about biodiversity and the dangers of removing parts before knowing the role they play in a system.

CONCEPTS

- Forests are complex ecosystems.
- Birds are part of forest ecosystems.

OBJECTIVE

Students will be able to understand the need to conserve biodiversity.

KEY POINTS

- People need to conserve biodiversity, even if we don't know the importance of all the components of an ecosystem.
- A living creature or an ecosystem is more complex and harder to put back together again than a humanmade machine.

TEACHER BACKGROUND

Biodiversity (or biological diversity) is defined simply as the variety of life. It is usually thought of in three ways. First, and most commonly, we refer to species diversity, the variety of species present in a given area. For instance, we can speak of species biodiversity in a particular forest, meaning all fungi, protozoa, bacteria, animal and plant species. Sometimes, rather than counting each species equally in measuring species diversity, one species may be given more weight. This procedure is done in the case of a rare or endangered species, for the loss of a few could deplete biodiversity by reducing the number of species present.

Biodiversity is also used to describe genetic diversity, which is defined as the variability present in a particular gene pool of any given species. Usually, the more diverse the gene pool, the healthier the species, as diversity allows for adaptation and change over time.

Finally, biodiversity can refer to ecosystem diversity. Ecosystems are systems where there is an exchange of materials between the living and nonliving components. This diversity can be an indication of the variety of populations and communities in a given region. A national forest may contain coniferous and deciduous forests and lake and stream ecosystems. The deciduous forest itself contains a variety of ecosystem types, such as in the canopy and the forest floor. Greater ecosystem diversity often contributes to greater species and genetic diversity.

However we define biodiversity, it is dynamic, changing. For example, through geologic time, the climate has changed enough to greatly alter diversity with the advance and retreat of glaciers. On local levels, we may see changes in diversity through human interactions with the environment, such as clearing woodlands for agriculture or discharging untreated waste water into streams. Biodiversity also changes continuously through dispersal mechanisms and adaptation strategies of individual species. If a particular habitat becomes less desirable for a species, the species may be able to thrive by migrating or dispersing to another area. Or, a species having higher genetic diversity may be capable of adapting to the changes within its environment.

Generally, the more specialized or isolated a species is, the more vulnerable it is to environmental change. A species that exists only in a small area, such as an island, can be destroyed completely in a single storm. A

species can be driven to extinction by human activity, as was the passenger pigeon (*Ectopistes migratorius*) due to excessive, unregulated hunting and dramatic changes in available habitat. Many species suffer from human actions, such as destruction of suitable habitat like wetlands or land conversion from forests to suburbs and shopping malls. In some places, the loss of large amounts of contiguous forest habitat has been associated with declining populations of many species.

Maintaining biodiversity is an important goal for humankind, given that the variety of life is more threatened today than in any time since the extinction of the dinosaurs 65 million years ago. The dodo bird (*Raphus cucullatus*), passenger pigeon and Labrador duck (*Camptorhynchus labradorius*) have all become extinct, while the whooping crane (*Grus americana*), red-cockaded woodpecker (*Picoides borealis*) and Kirtland's warbler (*Dendroica kitlandii*) have been declared endangered.

In the United States, the Kirtland's warbler is on the Endangered Species list. From 1961 to 1971, the population of Kirtland's warblers decreased to dangerously low levels, primarily due to parasitism by the brown-headed cowbird (*Molothrus ater*). (See "Cowbird Capers" for more information on cowbird parasitism.) With a massive recovery plan, which included cowbird control, the warbler's population stabilized. There is now evidence that suitable breeding habitat is the limiting factor in this warbler's recovery. This species breeds in a very specific habitat of dense, young jack pine (*Pinus banksiana*) stands found in Michigan. Historically, jack pine required naturally-occurring fires to reproduce. The heat of the fires was necessary to open the cones and release the seeds. Due to fire prevention, this habitat became limited. In addition to cowbird control, recovery efforts now include developing and maintaining suitable nesting habitat on a sustained basis, including planned rotation cuttings of jack pine stands within designated management areas.

Why care about maintaining biodiversity? Given the present rate of habitat degradation and loss, particularly in the tropics, 15 percent of all species may become extinct in the next few years. The implications of such loss are immense. As humans, we are subject to the moral and aesthetic aspects of such destruction. Unfortunately, these aspects are hard to quantify and categorize and therefore often get overlooked and omitted from the conservation equation. Other implications are more concrete, such as alteration of ecosystems to the extent that the change affects climate and important ecosystem functions such as cycling nutrients, purifying water and removing wastes. Jeopardizing ecosystem functions could hamper sustainable production of some crops on which humans depend. We are just beginning to realize what unknown adverse impacts may occur as a result of the loss of biodiversity.

Loss of species diversity can mean the destruction of potential but not yet identified resources, such as medicine and food. For example, recent research has found that the bark of the Pacific yew (*Taxus brevifolia*), a tree that grows in the Pacific Northwest, contains the makings of a drug, taxol. Taxol is used in treating certain types of cancer in humans. Before anyone discovered this potential use of the Pacific yew, the tree was not considered economically important and was often burned as waste during logging operations.

Humans can take positive steps to conserve biodiversity. The bald eagle (*Haliaeetus leucocephalus*), our national symbol, was endangered because of pesticides in the food chain. By limiting use of certain pesticides, such as DDT, we reduced the pesticides' residues in the food chain and improved the quality of the eagle's food source. In large part due to these efforts, the bald eagle's status has been redefined from endangered to threatened in Illinois and federally, and it has now been removed from the endangered and threatened list.

To protect species and genetic diversity, we have to maintain habitats and ecosystems. One way to do so is through the creation and management of parks and reserves. **Preservation** is one strategy; the maintaining of a natural environment undisturbed by the influence or activities of humans. However, this approach alone is simplistic and will not be effective in the long run. Natural succession will change the ecosystem, even if humans do not interfere. Nor will we be able to set aside enough land to preserve biodiversity, in part because competition often comes from increasing human populations, and our need for resources often prevents such preservation.

Many countries in the tropics are experiencing a human population explosion. Nicaragua, for example, had a population of 1.1 million in 1950, 3.87 million in 1990 and is projected to be at 9.22 million by the year 2025. This increasing human population in Nicaragua and other developing countries will necessitate the use of more land and food resources, potentially at the expense of biodiversity. In the United States, despite much slower human population growth, specialized habitats such as wetlands are often compromised for development, and we've lost most of our prairies and savannas already. It is estimated that people in the United States use up to 30 times more resources per person than most of the third world does.

While there is a need to preserve some areas, here and in the tropics, we also will have to work within managed

lands to conserve as much biodiversity as possible, while still producing commodities for humans. **Conservation** is the protection, improvement and wise use of natural resources to assure the attainment of the highest economic and social values for perpetuity. Ultimately, conservation will allow for wise use of resources and maintenance of biodiversity.

In order to conserve biodiversity, we have to understand that all species and ecosystems have value. Because it is not feasible to measure all biodiversity, nor to understand all present and future values of each living species, we have to act intelligently when we alter natural environments. As Aldo Leopold succinctly suggests in his essay “Round River,” we should not undervalue or discard a resource just because we're not sure of its use.

"Have we learned the first principle of conservation: to preserve all the parts of the land mechanism?...To save every cog and wheel is the first precaution of intelligent tinkering."

PROCEDURE

1. Divide the class into cooperative groups of four. Assign each student a role as follows: a) a Labeler to label parts; b) a Recorder to write down each part's function; c) a Disassembler to take the pieces apart; and d) an Assembler, to put the item back together.

2. Give each group an old, junked radio, clock or other piece of machinery. Instruct them to separate it into as many individual pieces as possible **in ten to fifteen minutes**. Have the Labeler and Recorder label each piece with its name and its function in that particular piece of equipment. If students are not sure exactly what a piece is called or what it is used for, have them write a "?" for that piece. There should be lots of question marks.

3. Have students throw away all the pieces labeled with a "?."

4. Instruct the Reassembler to put together the original piece of equipment, using only the pieces that are left. Students will immediately realize that this is impossible. Ask if their machinery is fixed.

5. Read them Leopold's line: "To save every cog and wheel is the first precaution of intelligent tinkering." Discuss the meaning of "intelligent tinkering." Compare the machine or appliance to an ecosystem. Point out that a forest ecosystem, once altered or destroyed is harder to reconstruct than a human-made machine.

6. Define biodiversity. Discuss the importance of biodiversity and its conservation. Discuss the importance of considering biodiversity in land-use decisions, along with the many other valid concerns: the need for agricultural expansion; housing development; conservation of other wildlife habitat; fuel wood; etc. Define and discuss the difference between conservation and preservation. Discuss ways we, in temperate climates, can help conserve biodiversity in tropical climates. Students may suggest international conservation treaties, trade agreements or education efforts.

7. Ask members how the group performed. What did your group do well? What does your group need to work on?

DISCUSSION

1. Was anyone able to repair their piece of machinery? If machines, which are created by people, are complicated to understand, how complex are living things? If a flower were plucked or a bird killed, could you fix the flower so it would function again making nectar, or the bird so it could sing or fly? What about a whole ecosystem? If a forest is destroyed, can you recreate it overnight?

2. Why is it important to save all the pieces, even those we can neither name nor identify by purpose? What pieces have we already lost? Which ones are we in danger of losing? How is your toaster/radio/clock like an ecosystem? How is it different? How are the parts like individual species? How are they different? Does the ecosystem stop working when one or some parts are removed? Can it function in a different manner?

3. Is it important to conserve biodiversity? Why? Is the loss of any single bird a big deal? Why, or why not? Is conserving biodiversity important only for humans? Do you think people in Latin America think the same way about the need to conserve biodiversity as you do?

4. What human interests and needs may conflict with conserving biodiversity? Is it appropriate to set aside large tracts of forest solely for the benefit of wildlife? Can we use forests in such a way that biodiversity can be conserved? What might happen if we tried to preserve all forests without any disturbance from human activity?

MODIFICATIONS

Have each class work on one large machine during one day, so each class takes the machine apart a little further during their class period. The next day, have classes try to put the machine back together. This process will be very difficult because students don't know what parts

other classes removed. Compare this activity to the way an ecosystem may be changed by many generations of people, each knowing little about the alterations made by previous generations.

If you don't have access to machines or tools, try this activity. Ask each group to pick four letters that are not next to each other in the alphabet, including at least one vowel. Give cooperative groups a word search puzzle, withholding for a moment the key words and the fact that the block of letters is a word search. Write the four selected letters on top of their page. Next, instruct them to cross out these four letters each time they appear on the page. Supply the students with the key words and tell them the writing on the page is a word search. Ask them to find as many of the key words as they can in the search, but they can no longer use the letters they've crossed off. After they've worked on it, ask how many of the words they were able to find. Ask if they would have chosen different letters to cross out if they had understood the letters' roles in the word search. Continue with procedures five and six from above and conduct the discussion.

EXTENSION

1. Read and discuss Tennyson's poem as it relates to the complexity of living things and our ability to comprehend biodiversity.
2. In cooperative learning groups, have students conduct research on threatened or endangered species to find out about limiting factors and conservation efforts.
3. Take students outside and mark off a small area with a hula hoop or circle of string for each cooperative group. Each group must determine, as well as they can, how many different species of plants and wildlife are living in their circle. Relate this activity to a discussion of biodiversity.

ASSESSMENT

1. Evaluate student performance in cooperative groups.
2. Have students write down why you had them take apart machines.
3. Ask students to define "biodiversity," "conservation" and "preservation."