Project Learning Tree
Secondary Environmental Education Program

EXPLORING ENVIRONMENTAL ISSUES:

BIODIVERSITY

Acknowledgments

Support for this module was provided by:

World Wildlife Fund
Washington D.C.

Geraldine R. Dodge Foundation
Morristown, NJ

Project Learning Tree is a program of the American Forest Foundation.

American Forest Foundation

Penn Siegel
Chair

Laurence Wiseman
President

Pam Rockland
Vice President, Development

Project Learning Tree Staff

Kathy McGlauflin
Senior Vice President

Rachel Bayer
Manager of Operations

Vanessa Bullwinkle
Director of Operations and Marketing

Catherine Estes
Senior Manager of Curriculum and Outreach

Jackie Stallard
Program Assistant

Al Stenstrup
Director of Curriculum Programs

Writers

Sheri Sykes Soyka
Vienna, Virginia

Sara St. Antoine
Boston, Massachusetts

Luise Woelflein
Anchorage, Alaska

Editor

Publications Professionals LLC

Design

TM Design, Inc.

Reviewers

James Barresi
New Jersey Forest Service

Gary Boyd
International Paper

Judy Braus
National Audubon Society

Carolyn Cohen
U.S. Bureau of Land Management

Shawna Crocker
Colorado PLT

Katie Friday
U.S.D.A. Forest Service

Frank Gallagher
New Jersey Department of Parks & Forestry

Michelle Mauthe Harvey
MautheHarvey & Co.

Drew Marczak
Plum Creek Timber Company

Safiya Samman
U.S.D.A. Forest Service

Bora Simmons
Northern Illinois University

Jim Stark
Weyerhaeuser Company

Patti Vathis
Pennsylvania Department of Education

Rick Zenn
World Forestry Center

Project Learning Tree State and International Coordinators

For a current listing of Project Learning Tree Coordinators, visit www.plt.org.

Biodiversity Background Information for Educators

Biodiversity! Although the term may seem intimidating to some, you couldn't choose a more engaging and stimulating topic—or one as all-encompassing and important for our future.

Biodiversity is the variety of life on Earth. It's everything from the tiniest microbes to the tallest trees, from creatures that spend their entire lives deep in the ocean to those that soar high above the Earth's surface. It's also the word used to describe the wealth of habitats that house all life forms and the interconnections that tie us together. All of Earth's ecosystems and the living things that have evolved within them—including the fantastic range and expression of human cultures—are part of our planet's biodiversity.

and porpoises. It is also reflected within each species through ***genetic diversity***. In other words, no two blue whales have the same exact genetic make-up. The variety of species, the variety of genes within a species, and the variety of ***ecosystems***, where species live, are all critical components to understanding the interconnections that support all life on our planet.

Defining Biodiversity

Biodiversity is short for biological diversity. It refers to the biological variety at all levels of organization within our environment, including genetic variety within a ***species*** population, and species variety within an ecological community.[1] Biodiversity is reflected in our oceans, for example, with the over 75 species of Cetaceans, which include whales, dolphins,

The Function of Biodiversity

We humans are late additions to an incredibly complex and interdependent web of life that has been evolving on this planet for at least 3.5 billion years. Humans are dependent on biodiversity for most, if not all, of our needs. A significant loss of biodiversity could seriously undermine our long-term economic, intellectual, physical, and emotional well-being.

We're learning how a number of species, including humans, may depend on certain ***keystone species***. Imagine that a species of wild bee has become extinct. The plants that depend on the bee for pollination and the animals that rely on the plants for food could be adversely affected by such a loss—and so might the farmers whose crops need the bees for pollination. Also at risk are local economies that rely on uninterrupted and bountiful harvests.

Pacific Yew Foliage

Pacific Yew Bark: Dave Powell, USDA Forest Service, www.forestryimages.org

Or consider the Pacific yew, a small understory tree found almost exclusively in the forests of the American Northwest. The yew is a unique natural source of a potent anticancer drug called Taxol. After years of research, scientists have discovered a method to synthesize the production of Taxol, which has provided what some call one of the most significant advances in cancer therapy. But if the last of the forests had fallen before the discovery of natural Taxol, there might currently be no model for the creation of a synthetic version. And cancer research might not have come as far as it has to date.

What other useful compounds remain undiscovered in wild species living in threatened habitats around the world? Could an obscure grass, now hanging onto survival in North America's remaining patches of tallgrass prairie, contain the genes needed to make corn resistant to a new disease? Or could a fungus found only in a tropical rainforest hold the key to a new antibiotic? What we do know is that we're just beginning to understand the wealth to be found in the life all around us.

Only a small percentage of the forms of life on Earth have been studied. How many different forms of life exist? The process of determining the number is not easy. The United Nations Environment Programme's Global Biodiversity Assessment estimates the number of described species at approximately 1.75 million. Because there are differences in the way organisms are classified and named, this number will likely always be an estimate. An even greater mystery is how many species may exist on Earth today. Estimates for the total number of species on the planet range from 5 million to more than 30 million.

If our well-being is so dependent upon biodiversity, why aren't we more aware of it? The answer may be partly a result of our loss of intimacy with other living things. As we have moved from walking the land to hurtling past it on paved roads, from hunting and growing our food to buying it at a store, from dipping water from a stream to turning on a faucet, we've lost contact with the natural foundations on which our lives are built. Most of us can now get along just fine without knowing about weather patterns, soil conditions, water sources, or the migration patterns of game.

Some say it's okay to lose our knowledge of nature because it's not relevant to modern life. But others say our ignorance is catching up with us. They suggest that we may be oblivious to the incremental—but important—changes in the health of our natural environment, and that we're thus letting biodiversity slip away without realizing the value of what we're losing.

Determining Biological Importance

Certain ecosystems around the world harbor especially large numbers of species. The most familiar are tropical rainforests. The forests of

New Guinea, for example, are home to about the same number of bird species as the United States and Canada combined—yet the island covers less than 3 percent of that area. Other incredibly diverse ecosystems include coral reefs, large tropical lakes, and parts of the deep-ocean floor. In general, scientists consider ecosystems with naturally large numbers of species to be among the most important ones to focus on in the effort to conserve biodiversity. But the number of species is just one measure of an ecosystem's importance. Other factors related to determining ecosystem importance include complexity of habitat—from the types and abundance of species to the physical landscapes within it. Still another factor is whether the ecosystem performs a key function, such as flood control or water purification. Scientists also consider whether an ecosystem is threatened when determining its biological importance.

Biodiversity—from Distant Rainforests to Your Town

Many scientists use the term "Biodiversity hotspot" when referring to a geographic region in which there is an extraordinarily large concentration of species that evolved in that region.[2] Hotspots are found in ecosystems such as rainforests and coral reefs. According to Conservation International, "nearly three-quarters of the world's most threatened birds, amphibians, and mammals and over half of all the world's plants live in just a tiny fraction of the Earth's surface – the biodiversity hotspots." The majority of these species cannot be found anywhere other than the 34 hotspots that Conservation International has identified.[3]

Hotspots also include ecosystems that have a large number of ***endemic*** species—those that are found nowhere else on Earth.[4] Islands in particular, both large and small, are rich in endemic species. Madagascar—with its incredible diversity of lemurs—is a classic example of island uniqueness.

Although scientists are justifiably concerned about saving unique ecosystems or those with the most diversity, many also agree that it is important to conserve the biodiversity remaining in our most settled or disturbed regions, such as vacant city lots, suburban backyards, and heavily cultivated farmland. The value that biodiversity provides does not decrease in areas where human activity has already taken its toll. In fact, where biodiversity has been lost, the remaining species may become that much more precious. And where we have done the most damage, perhaps ethics demand that we are even more obligated to preserve what is left and to restore what was once there.

Our Important Role in Protecting Biodiversity

One of the greatest challenges we face in protecting biodiversity is how to balance the needs of the present without jeopardizing those of the future. We're finding that there's no one way to address this challenge—in part because there's no one reason that we're losing biodiversity. Ensuring the survival of species, genes, and ecosystems will require a combination of many approaches, as well as the collective thinking of people from all disciplines and backgrounds.

Stewardship, Citizenship, and Democracy

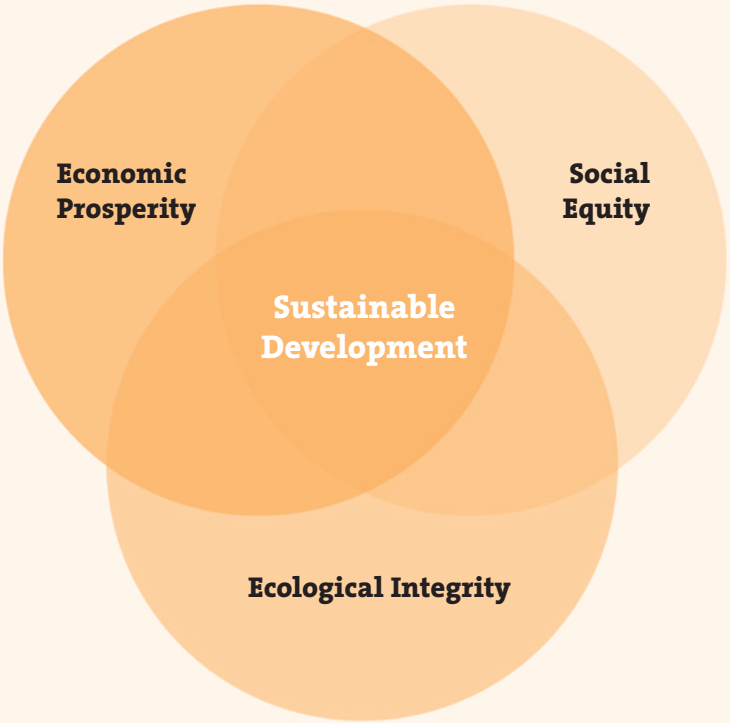
One of the most important things that we can do to conserve biodiversity is to get involved—in our roles as parents, community members, educators, landowners, voters, employees, employers, politicians, and business leaders. For many, that involvement means changing the way we educate our children and ourselves about what it means to be a citizen in a democracy. As Frances Moore Lappé and Paul Martin DuBois say in *The Quickening of America*, "Democracy requires a lot more of us than being intelligent voters. It requires that we learn to solve problems with others—that we learn to listen, to negotiate, and to evaluate. To think and speak effectively. To become partners in problem solving."

There are thousands of examples of individuals and communities working together to solve biodiversity problems. They're forming citizen groups to restore habitats, writing letters to elected officials, lobbying on biodiversity issues, taking action as company shareholders, using the media for communication campaigns, raising money for environmental and social organizations, educating fellow employees, conducting workshops on consumer issues, setting up information clearinghouses, volunteering for conservation organizations, and forming community stewardship councils. But many people agree that we still have a long way to go before the majority of U.S. citizens have the confidence, the know-how, the opportunity, and the commitment to bring about changes that ensure the conservation and restoration of biodiversity.

Living Sustainable Lifestyles

Conserving biodiversity and finding solutions to the intricately connected problems of environmental degradation, social decline, and economic

One View of Sustainable Development



"Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs. Choosing to be sustainable in businesses, schools, government institutions, and our individual lives demands a national commitment to the nation's economic prosperity, ecological integrity, and social equity." Source: President's Council on Sustainable Development, April 1995.

instability will mean feeling, thinking about, and doing things different from the ways we have before. It will mean fostering more compassion for other species and a kind of reverence for living systems that are too complex for us ever to understand fully. It will mean educating ourselves about the connections among all elements of biodiversity and between a healthy natural environment and a healthy human society. And it will mean coming to terms with the consequences of our behavior for other people and other species.

Conserving biodiversity will require us to incorporate the concepts of social equity and ecological integrity into how we do business. It will challenge us, in every aspect of our lives, to work toward creating a more sustainable society—one in which human needs are in balance with the needs of other living things. And it will mean developing not only a conservation ethic but also an entire belief system that honors the integrity of the Earth and of ourselves.

Why Study Biodiversity?

The diversity of life on Earth shapes and nourishes every facet of our existence. But because those connections are seldom obvious, we humans have often pursued our short-term interests with limited regard for the well-being of other species and the places they live. At the same time, social and economic forces have caused some people to exploit resources to meet their basic needs. As a result, biodiversity is rapidly declining. If we want to ensure the long-term health of the planet, we need to develop an informed and motivated citizenry that understands what biodiversity is and why it's important. And we need citizens who have the skills and confidence to rise to the challenge of protecting biodiversity and who feel empowered to do so. Education, we believe, is one of the best tools we have for achieving that goal.

Through the study of biodiversity, students will start to see more clearly the invisible connections that bind our lives to other life forms. As they come to understand those connections, perhaps they will gain a new perspective on their place in the natural world. And in the process, they may learn not only how to better protect the living things on which they depend, but also how to create a more sustainable and responsible society.

We also believe that biodiversity is an important and powerful issue that draws learners in. As a theme, it cuts across many disciplines and provides real-world contexts and issues that promote critical and creative thinking skills, citizenship skills, and informed decision making. Biodiversity also illustrates the complexity of environmental issues and makes plain that there are many perspectives as well as much uncertainty.

Endnotes

1 Schmitz, Oswald J. *Ecology and Ecosystem Conservation.* Washington, DC: Island Press, 2007.
2 Ibid.
3 Conservation International. "The Hotspots." http://www.conservation.org/explore/priority_areas/Pages/hotspots.aspx (accessed April 10, 2008).
4 Miller, Jr., G. Tyler. *Living in the Environment*, 14th Ed. Pacific Grove, CA: Thomson Learning, Inc., 2005.

Information for this background and the accompanying activities has been reprinted or modified with permission from ***Windows on the Wild: Biodiversity Basics*** *by the World Wildlife Fund, 1999, published and distributed by Acorn Naturalists, 155 El Camino Real, Tustin, CA, 92780.*

1 Global Invaders

People have intentionally and unintentionally moved plant, animal, and other species to new environments. Many of those species cause environmental—and sometimes economic—harm. In this activity, students will research invasive species in the United States and then investigate the presence and effects of invasive species in their own community.

Level
Grades 9–12

Subjects
Biology, Ecology, Economics, Environmental Science, Geography, Social Studies

Concepts
1.1; 1.6; 2.6.
See the Conceptual Framework for a complete description of the concepts.

Skills
Analyzing, Defining Issues, Discussing, Organizing Information, Presenting, Researching

Materials
Copies of the student pages and a map of the world. If possible, access to the Internet and to word processing and to presentation software.

Time Considerations
Part A: Three 50-minute periods.
Parts B and C: One 50-minute period each.

Related Activities in Other PLT Guides
PreK-8 Guide: Planet Diversity; Charting Diversity; Invasive Species; Web of Life; The Global Climate.

Focus on Risk module: Decision Making: Ecological Risk, Wildfires, and Natural Hazards.

Forest Ecology module: Adopt-a-Forest; Home Sweet Home.

Places We Live module: Green Space; Far-Reaching Decisions.

Objectives
- Students will learn what invasive species are and will understand several of the economic and ecological problems associated with them.
- Students will develop an understanding of some of the issues and conflicts surrounding invasive species control.
- Students will identify and research invasive species in the local community to learn how they spread, what their effects are on the environment or economy or both, how they are being controlled, and how they are affecting biodiversity.

Assessment Opportunities
- Use students' "Understanding Invaders Worksheet," their class presentations, and other homework assignments to assess these: How well do students understand the concept of invasive species? How well did they communicate the issues and conflicts with invasive species control? Did they offer solutions for preventing further spread of invasive species? How creative were they in getting across their message?
- Use the "Content Questions" student page to assess student understanding.

Background

In Brooklyn and Chicago, residents spot unusual, voracious beetles boring through hardwood street trees. In California, scientists track the spread of Africanized honeybees from South America. In Maryland, officials poison three ponds after anglers discover a population of predatory snakehead fish from China.[1]

All around the world, ***nonnative species***—from microbes to mussels to monkeys—are arriving in unexpected places. A nonnative species is any species that has been taken from its native habitat and transplanted to a new environment. Nonnative species do not always disrupt their new-found habitat, but when they do, the costs can be enormous.

When the introduction of a nonnative species causes or is likely to cause economic, environmental, or human health damage, it is called an invasive species. An ***invasive species*** is defined as a species that is

1. nonnative to the ecosystem under consideration, and
2. whose introduction causes or is likely to cause economic or environmental harm, or to cause harm to human health.

Invasive species can be plants, animals, or other organisms (for example, microbes). In their new locations, invasive species do not have the natural controls that serve to limit their population in their native range. This lack of limits, coupled with the fact that they typically have a high rate of reproduction and are tolerant of a large array of conditions, enables them to thrive and even dominate in nonnative areas. See "Common Characteristics of Invasive Species" on the following page.

Common Characteristics of Invasive Species

The more of the following characteristics that an introduced species possesses, the more likely it is to become invasive and to threaten the environment:

- **Tolerates a wide range of conditions**
  Example: The European starling can live in a variety of habitats from woodlands to open fields to cities.

- **Has a long growing season or short generation time**
  Example: Common buckthorn has a much longer growing season than native plants.

- **Has few natural controls such as predators, diseases, or insects**
  Example: Leafy spurge is inedible to the native insects and animals of the American West; it has greatly reduced the populations of plants that native species can eat.

European starlings

- **Disperses itself with ease**
  Example: Cogongrass was introduced from Southeast Asia into the southeast United States in the early 1900s to help control soil erosion. Each plant produces several thousand seeds that can be dispersed up to 15 miles by wind.

- **Produces lots of seeds or eggs**
  Example: One zebra mussel can release up to one million eggs per year.

- **Enjoys a new location that has climate and environmental conditions similar to native habitat**
  Example: Burmese pythons have invaded the Everglades after pet owners have released them into the wild. Global climate change could result in more foreign tropical species finding their way to, and prospering in, nonnative tropical environments.

Zebra mussels

Scientists believe that invasive species are among the most significant threats to ***biodiversity*** at every level. Although habitat loss and pollution have gained more attention as causes of biodiversity decline, invasive species have steadily been pushing hundreds of native species into threatened or endangered status, thus driving many endangered species to the point of extinction. Scientists have calculated that nonnative species are taking a toll on 49 percent of all endangered species.[2] And they think that nonnative species have played a role in 25 percent of known fish extinctions, 42 percent of reptile extinctions, 22 percent of bird extinctions, and 20 percent of mammal extinctions.[3]

The nonnative species that cause the most problems are usually fast-reproducing and are adaptable to a variety of habitats and prey. And they often arrive in the new location without any, or enough, predators to control them. Those species can quickly alter an ecosystem in dramatic ways, such as decimating prey populations, outcompeting other predators for a particular prey species, and changing the structure of a habitat. For example, introduced dogs, pigs, and rats in Hawaii have preyed on many ground-nesting bird species, driving many of them to extinction.[4] Zebra mussels have caused native freshwater species to decline by filtering out tremendous amounts of the phytoplankton upon which they all depend.[5] Purple loosestrife, an escaped ornamental plant, has replaced cattails in many U.S. wetlands, creating habitats unsuitable for nesting bitterns and other native species.[6] (See the "Invasive Species in the United States" box on this page for a list of some common invasive species in the United States by region.)

In addition to those ecological costs—which affect humans and wildlife alike—invasive

Invasive Species in the United States

The following is a small sample of troublesome invasive species found in different regions of the United States.

Northeast
Asian longhorned beetle, common buckthorn, Dutch elm disease, European green crab, European gypsy moth, European starling, hemlock woolly adelgid, hydrilla, mute swan, purple loosestrife, West Nile virus

Southeast
Chinese tallow, cogongrass, European green crab, hydrilla, Japanese honeysuckle, kudzu, melaleuca, nutria, red imported fire ant, water hyacinth, wild boar

Midwest
Asian longhorned beetle, Dutch elm disease, Eurasian ruffe, Eurasian water milfoil, European gypsy moth, leafy spurge, purple loosestrife, sea lamprey, spotted knapweed, zebra mussel

West
Africanized honeybee, Chinese mitten crab, Chinese tallow, European green crab, giant reed, hydrilla, red imported fire ant, Scotch broom, spotted knapweed, sulfur cinquefoil

Southwest
Africanized honeybee, Asian clam, camelthorn, cheatgrass, fountaingrass, giant reed, red imported fire ant, tamarisk, toadflax

Hawaii
American chameleon, apple snail, black rat, Chinese tallow, Indian mongoose, Japanese honeysuckle, Miconia, red imported fire ant, strawberry guava, wild goat

species are creating big economic costs for people. The Atlantic comb jelly, for example, devastated stocks of anchovies and other native fish in the Black Sea, leading to an estimated $350 million annual loss in fisheries revenue.[7] A recent study of the potential effect of Asian longhorned beetles on American hardwoods estimates a loss of as much as $669 million nationwide.[8] In fact, scientists in the United States recently estimated that nonnative species as a whole have cost the country $137 billion annually in economic losses.[9]

With all the problems associated with invasive species, it should come as no surprise that people are working actively to try to prevent further invasions and to resolve existing problems. Unfortunately, there are no surefire control mechanisms. Invasive species are by definition aggressive, adaptable, and quick-spreading. And they are crossing borders through so many channels that it is hard to guess where and when they will show up next.

Still, many countries (including the United States) are trying to slow the influx of nonnative species by conducting regular customs inspections.[10] In addition, people are working to physically remove invasive plants from woodlands, wetlands, and other habitats, but this work has proved to be marginally effective, as well as extremely expensive and time-consuming.[11] Conservationists also have tried to remove invasive animals where they have taken up residence and then restore the ecosystems to their previous condition. Unfortunately, efforts to restore habitats once invasive species have become established are extremely expensive. So, experts agree that the cheapest and easiest way to control invasive species is still to prevent them from coming in at all.[12] (See the "How to Prevent Invasive Species" student page for more information.)

It is difficult to anticipate how invasive species will affect wild and human communities in coming years. Some scientists predict a gradual reduction in biodiversity, leading to the dominance of only the most adaptable, weedy species: rats, pigeons, starlings, cockroaches, house sparrows, raccoons, and humans.[13]

Others are hoping that increased efforts to prevent and control invasive species will pay off. In 1999, President Bill Clinton signed Executive Order 13112 instructing all federal agencies to stop activities that might be helping invasive species to spread. The order also called for the formation of a federal council to devise a management plan for invasive species.[14] The following website provides information on the Executive Order and the formation of the National Invasive Species Council. It also serves as the gateway to information, programs, organizations, and services dealing with invasive species: http://www.invasivespeciesinfo.gov.

Invasive species are not a new phenomenon, but globalization has brought increased worldwide travel and shipment of goods. Along with it an ever-increasing number of new invasions. There are many pathways by which invasive species end up in a new location, far away from their native range.

In some cases, people intentionally introduce them to the new area, not realizing the untold damage they might cause. For example, nutria are large rodents nearly the size of beavers. Nutria were imported to the United States from Argentina in the 1930s. The purpose was to raise them and produce furs. However, individuals quickly escaped, and by 1955 their population was already in the millions. This rodent can

Above: Purple loosestrife
Right: Nutria

cause millions of dollars worth of damage by ruining agriculture crops and by weakening levies. Another species, purple loosestrife, was intentionally introduced in the northeastern part of the United States in the 1800s as an ornamental plant and for its medicinal properties. Because purple loosestrife adapts readily to both natural and disturbed wetlands, it out-competes many native grasses and flowering plants, thereby negatively affecting waterfowl habitat.

In other cases, the introduction of invasive species is unintentional. People unknowingly transport species lodged in or on barges, boats, trailers, animals, vehicles, commercial goods, packing materials, produce, footwear, or clothing.

Many aquatic invasive species are transported to new regions by way of the ballast water of ships. Ballast water is taken into partially empty cargo ships to provide stability during ocean crossings. Then it is pumped out when the ships pick up their loads somewhere else. Some ships transport millions of gallons of water, laden with organisms, to other locales. Species such as zebra mussel and spiny waterflea were unintentionally introduced into the United States in this way, spreading through interior waterways while traveling on recreational boats and other human activities.

For some, the best way to reduce the negative effects of invasive species is to take a diversified approach: prevent every possible invasion, and aggressively combat those that accidentally occur.[15] Because such efforts will require the support and involvement of millions, public education also is an important part of combating invasive species. A good model, some say, is in Australia where as one person puts it "the average taxi driver" is already well informed about the power and destruction of invasive species.[16] Perhaps with good information, public support, and enough financial investment, invasive species can be kept at bay so that our native species can survive and flourish.

Endnotes

1 "Maryland State Officials Start Poisoning Alien Snakehead Fish." *USA Today*. August 18, 2002. http://www.usatoday.com/news/nation/2002-08-18-snakehead_x.htm (accessed December 13, 2006).
2 Cox, George W. *Alien Species in North America and Hawaii: Impacts on Natural Ecosystems*. Washington, DC: Island Press, 1999.
3 Ibid.
4 Merryl J. Mulroney "Birds in the danger zone - scientists work to save forest birds of Hawaii." Ranger Rick. June 1998. http://findarticles.com/p/articles/mi_m0EPG/is_n6_v32/ai_20620944 (accessed September 24, 2007).
5 National Atlas of the United States. "Zebra Mussels." nationalatlas.gov/articles/biology/a_zm.html. (accessed September 24, 2007). See also Wittenberg, Rüdiger and Matthew J. W. Cook, eds. *Invasive Alien Species: A Toolkit of Best Prevention and Management Practices.* Cambridge, MA: CABI Publishing, 2001.
6 Great Lakes Information Network. "Purple Loosestrife in the Great Lakes Region." November 2006. www.great-lakes.net/envt/flora-fauna/invasive/loosestf.html (accessed December 13, 2006).
7 U.S. Department of State. "Case Study: American Atlantic Coast Comb Jelly." www.state.gov/g/oes/ocns/inv/cs/2313.htm (accessed December 13, 2006).
8 Nowak, David J., Judith E. Pasek, Ronaldo A. Sequeira, Daniel E. Crane, and Victor C. Mastro. "The Potential Effect of Asian Longhorned Beetle (Anoplophora glabripennis) on Urban Trees in the United States." An abstract prepared for the USDA Interagency Research Forum on Gypsy Moth and Other Invasive Species. January 16–19, 2001. Annapolis.
9 Pimentel, David, L. Lach, R. Zuniga, and D. Morrison. "Environmental and Economic Costs Associated with Non-Indigenous Species in the United States." *Bioscience* Vol. 5 (2000): 53–65.
10 USDA National Agriculture Library. "Laws and Regulations." www.invasivespeciesinfo.gov/laws/publiclaws.shtml (accessed December 13, 2006).
11 Wittenberg and Cook. *Invasive Alien Species*.
12 Union of Concerned Scientists, "Science of Invasive Species." www.ucsusa.org/ssi/invasive_species/science-of-invasive-species.html (accessed December 13, 2006).
13 Quammen, David. "Tallying the Losses of Earth's Animals and Plants." *Harper's Magazine.* October 1998.
14 USDA National Agriculture Library. "Laws and Regulations: Executive Order 13112." http://www.invasivespeciesinfo.gov/laws/execorder.shtml (accessed December 13, 2006).
15 Kaiser, Jocelyn. "Fighting Back: Stemming the Tide of Invading Species." *Science*, Vol. 285. no. 5435 (1999): 1836–1841.
16 Ibid.

Getting Ready

Part A

- Make copies of the first six student pages. (Plan to divide your class into six teams. Each team will be assigned to one of the nonnative species arrival stories. Make enough copies of each story so that every team member has one.)
- Make enough copies of the "Understanding Invaders Worksheet" student page for each student.
- You may also want to make a copy of the "Useful Websites on Invasive Species" student page for each team or student.
- Arrange for class time on the Internet if you prefer to have students do their research during class.
- Gather audiovisual aids for your students to use in their presentations (for example, maps, easels, flip charts, and colored markers). Possibly arrange for students to do PowerPoint or similar presentations.

Part B

- For this day, you will want to decide whether to invite a speaker to your classroom or whether to take your students out into the field. Resources for finding speakers who are knowledgeable about invasive species include regional offices of the USDA Forest Service, state and field offices of the Bureau of Land Management, state departments of natural resources or state wildlife agencies, and local nature centers.
- Encourage the speaker to prepare an engaging, clear lecture and to bring visual aids or samples of invasive species, where appropriate.
- If you take your students into the field, decide whether you would prefer to take them on an informative hike or involve them in a service project. Check with nature centers, arboretums, departments of natural resources, or wildlife agencies for ideas on where to go, whom to have along as a guide, and what to do.
- Arrange for transportation, and give students permission slips in advance.
- Visit the site beforehand to anticipate any special issues that might arise while your students are there.
- The "Useful Websites on Invasive Species" student page includes links that provide information on regional offices that may be helpful in finding speakers and locating field sites.
- Make copies of the "How to Prevent Invasive Species" student page for each student.

Part C

- Make copies of the three "Nonnative Controversy" student pages.
- Plan to divide your students into three teams for this part. Each team will be assigned to one of the controversy stories.
- Make enough copies of each story so that every team member has one.

Doing the Activity

Part A: Understanding Invaders

1. Introduce the topic of nonnative species.

- Ask the students if any of them can define a nonnative species.

Answer: A nonnative species is one that has been introduced to a new area from its original territory.

- Are nonnative species a problem?

Answer: Students may know that some nonnative species are beneficial, some are harmless, and some are damaging.

- Can the students provide any examples of nonnative species from each group (beneficial, harmless, damaging)?

Sample answers: Wheat, soy, and chickens have been beneficial. Imported cherry trees, daisies, and Japanese maples have been harmless. European starlings, Scotch broom, purple loosestrife, and zebra mussels have been damaging.

- Discuss the difference between a ***nonnative species*** and an ***invasive species***.

Answer: A nonnative species is any species that has been taken from its native habitat and transplanted to a new environment. When the introduction of a nonnative species causes—or is likely to cause—economic, environmental or human health damage, it is called an invasive species.

- Overall, how big of a concern do students think nonnative species are?

Answers will vary. You may want to hold off on answering this question for the students until they have had time to learn more about the topic. See Background for information on this topic.

Tell the students that this weeklong unit will introduce them to nonnative species found throughout the United States and in their local community.

2. Divide the students into six teams. Have each team gather in a different part of the room. Assign each team to one of the six nonnative species arrival stories. Give each team member a copy of their team's assigned story. Give each student a copy of the "Understanding Invaders Worksheet."

3. Have the students read their assigned story and fill out their worksheet. Tell the students to answer the questions. You can decide if you want them to work alone or with team members on this project. For the final question, tell them that there are no right or wrong answers. Ecosystems are so complex that no one can guess perfectly how a newly introduced species will end up affecting the ecosystem. But tell your students that they should be able to make some good predictions by using the information provided.

4. Collect student worksheets and describe the assignment. Once your students have turned in their worksheets, tell them that their homework assignment is to gather more information on their assigned nonnative species using books, publications, magazines, and information on the Internet. You may want to give them a copy of the "Useful Websites on Invasive Species" student page. Have them try to find the answers to these questions:

- What are the main characteristics of this nonnative species? (For example, is it a plant or animal? What is its physical description?)
- Where did it come from and how did it get to its new location?
- What effects has this nonnative species had on the ecosystem? Or, if it has only recently arrived, what effects do scientists predict it might have? Be sure to describe benefits as well as drawbacks.
- What factors contributed (or might contribute) to the spread of this species?
- What factors might constrain its spread?
- What methods have people suggested or tried to contain this species?

Note: You may also want to pass out permission slips on this day if you are planning to take your students on a field trip on day four.

5. Have the students meet in their teams to pool their answers to the previous day's questions and to prepare an interesting and well-organized presentation for the rest of their class about the species they researched. Remind students that their presentation should address the questions posed in their homework assignment.

6. Tell the teams to try to limit their presentations to about five minutes. Visual aids should be encouraged. For example, the teams may want to point out on a world map where the species came from and where it has since spread. They may want to show images of the nonnative species. And they may even want to prepare their talks in PowerPoint. Tell the students that any preparations they are unable to make in class, they should finish as homework. Indicate what day will be devoted to class presentations. And remind them again of their time constraints: teams should time talks to be sure they will fit in a five-minute slot. If you do not want to enforce a time limit, you might plan on two days for class presentations and for the ensuing discussion.

7. Have the teams, one at a time, present the information on their species. Tell the other students to listen carefully because once the presentations are done, you will be asking them to discuss what they have learned. Select a student to serve as timer for the teams, unless you do not want to restrict the students.

8. Now that the students have had an opportunity to research their own nonnative species and to hear about several others, ask them to reflect on what they have learned. You might want to use the following questions to guide their discussions:

a. Do nonnative species all arrive by the same means? Explain.

Answer: No. People have intentionally introduced some invasive species to a new area, not realizing the damage they could cause. In other cases, the introduction of invasive species is unintentional; people unknowingly transport species lodged in or on barges, boats, trailers, animals, vehicles, commercial goods, packing materials, produce, footwear, or clothing.

b. Why might nonnative species be spreading more quickly today than they did several hundred years ago?

Answer: Globalization has brought increased world-wide travel and shipment of goods, resulting in an ever-increasing number of new invasions.

c. Using information from the presentations, can students generate a list of characteristics of invasive species that appear to make those species a great threat?

Answer: See "Common Characteristics of Invasive Species" earlier in this module.

d. All of the nonnative species assigned to the students are troublesome, or are expected to be troublesome for people, wildlife, and wild places. What are some of the problems associated with those species?

Answer: Nonnative species can outcompete and displace many native species. This change can cause substantial harm to desirable plants, animals, and entire ecosystems, as well as cause economic losses. Invasive species can degrade and alter habitats, crowd out native species, harm native species, choke waterways, ruin native fisheries, keep forests from regenerating, and compete with agricultural crops.

The eucalyptus tree, discussed in "California's Coastal Scrub," was deemed not suitable for lumber and the demand for firewood dropped off in the 1930s. By then, eucalyptus trees were rapidly spreading through, and outcompeting, native California woodlands. Native oak woodlands support at least 100 times more species than eucalyptus tree stands.

Sources for Step 8's Discussion Question Answers

Bureau of Land Management Wyoming. www.wy.blm.gov/cheatgrass/index.htm (accessed November 10, 2006).

California Academy of Sciences. www.calacademy.org/science_now/invasive_species/eucalyptus.html (accessed November 10, 2006).

Lutz, J. "Herpestes javanicus," Animal Diversity Web. 2003. animaldiversity.ummz.umich.edu/site/accounts/information/Herpestes_javanicus.html (accessed November 10, 2006).

USDA Forest Service. www.na.fs.fed.us/fhp/alb/albvideo/albvideo.shtm (accessed November 10, 2006).

USDA Natural Resources Conservation Service. plants.usda.gov/plantguide/pdf/pg_brte.pdf (accessed November 10, 2006).

U.S. Geological Survey. cars.er.usgs.gov/Nonindigenous_Species/Swamp_eel_FAQs/swamp_eel_faqs.html (accessed November 10, 2006).

U.S. Geological Survey. biology.usgs.gov/pr/newsrelease/2000/3-3.html (accessed November 10, 2006).

U.S. Geological Survey. nas.er.usgs.gov/queries/FactSheet.asp?SpeciesID=190 (accessed November 10, 2006).

University of Vermont Entomology Research Lab. www.uvm.edu/albeetle/ (accessed November 10, 2006).

The mongoose, discussed in "Hawaiian Islands," was introduced to control rats in sugar cane plantations. This change proved to be one of the worst attempts ever made at biological control. The mongoose did tremendous damage on its own account (eliminating many native species) and only partially reduced the populations of rats.

Asian swamp eels, discussed in "Florida Everglades", are predatory fish. They have no known predators in the United States to control their numbers. They have the potential to disrupt food webs and to compete with native species of fish and wading birds for food.

Asian longhorned beetles, discussed in "Chicago Hardwood Forests," attack and kill many hardwood trees, such as ash, birch, elm, horsechestnut, maple, poplar, willow, and many more. The Asian longhorned beetle has the potential to significantly disrupt forest ecosystems if it becomes established over a large area.

Cheatgrass, discussed in "Sagebrush Shrub Steppe," is a problem because it grows densely and outcompetes native grasses and shrubs. In the spring and summer, the dry cheatgrass is highly flammable and creates a fire danger.

The European green crab, discussed in "Atlantic Coastal Estuaries," is one of the most invasive predators in marine and estuarine habitats. It has caused many native species—some of commercial importance—to dramatically decline. For example, the European green crab has caused significant declines in scallops and is implicated in the destruction of the soft-shell clam fisheries in New England.

e. Do students know of any nonnative species present in their community? Are the species beneficial, neutral, or damaging? If they are damaging, have students heard about any controversies concerning how they are controlled?

Answer: See the box "Invasive Species in the United States" for a list of invasive species by region. Tell the students that in the remaining two days, they will learn more about invasive species in their community and the effects the species are having—Part B. Then they will have an opportunity to explore several controversies about managing invasive species—Part C.

Part B: Invasive Species in Your Community

Option 1: Invite a local expert to discuss invasive species and their effect on the local community. If possible, have the person bring a few examples of local invasive species into the classroom or provide visuals, such as a video or slide presentation. Encourage the students to ask the speaker questions.

For homework, have each student write a brief summary of what he or she learned about invasive species in the community and how the students think they should be managed. If the speaker has discussed several local invasive species, you may want students to pick just one for their report. Alternatively, have students create a display or presentation to educate others about a local invasive species.

Option 2: Organize a field trip or service day dealing with invasive species. Contact local parks or natural resources departments for suggestions. You might have a naturalist take the students to a protected area and point out the different places and ways in which invasive species have affected the area. If possible, have the naturalist describe other species invasions in the community that might not necessarily be visible in that area. Or have the students participate in a service day to restore areas affected by invasive species. They might clear areas of ailanthus or spotted knapweed, for example. Be sure that this activity is accompanied by informative commentary by a naturalist about how this and other invasive species are affecting the community and its biodiversity.

For homework, have the students write a summary about their experience in the field and what it taught them about local invasive species

issues. Alternatively, have students create a display or presentation to educate others about a local invasive species.

For both options: Discuss how students can help prevent the spread of invasive species. The best way to manage invasive species is to prevent their spread. Students should understand that they can help prevent the spread of invasive species in their community. Hand out the "How to Prevent Invasive Species" student page and review the information so students understand the suggested actions they can take.

Part C: Controversies over Invasive Species Control

1. Pass out copies of the "Nonnative Controversies" student pages. Organize the class into three teams. Have each team act out a skit based on information provided on the "Nonnative Controversies" student pages. Pass out copies so that each team has one controversy, and each member has his or her own copy. Explain to students that some of the methods used to control invasive species are quite controversial. Give the teams about 10 minutes to prepare a short skit demonstrating the conflict in their situation. As each team presents its skit, another team will serve as the decisionmakers, trying to resolve the conflict presented.

2. Have teams act out the "Nonnative Controversies." Allow members of each team to present their controversy. Before they begin, assign one of the remaining teams to serve as the decisionmakers on the issue. Team members will listen to the information presented, review the different sides of the argument, and then have two minutes among themselves to come up with a decision as to what should be done about the nonnative species. They should provide an explanation for their decision.

3. Discuss the decisionmakers' comments. Was their decision about how to manage the nonnative species fair to all parties concerned? Did it resolve the conflict?

4. Discuss methods that scientists use to control invasive species. Ask students if they can categorize some of the different methods that scientists have used to control invasive species as shown in the presentations.

Answer: Scientists have successfully controlled invasive species through biological, chemical, and mechanical methods, as well as by ecosystem management. Biological control involves controlling one organism with another organism. Chemical control usually involves the application of herbicides or pesticides. Mechanical or physical control methods include things such as mowing and hand-pulling of invasive plants, or inserting barriers such as nets that prevent fish from entering a river or lake. Ecosystem management involves regular treatment to an entire ecosystem—for example, a simulated natural fire that favors adapted native species over most invasive species.

5. Review with students how they can help prevent the spread of invasive species. Students should now understand that the best way to manage invasive species is to prevent their spread. Review the information on the "How to Prevent Invasive Species" student page to empower students to take action and to educate others.

6. As a final discussion question, ask students if any of them have changed their views of invasive species and the threats those species pose.

Answer: You might point out that scientists think that invasive species are one of the top threats to habitats and species worldwide. Invasive species are ranked the second biggest threat to biodiversity, with habitat destruction being the first.

California's Coastal Scrub

If you visit some parts of Marin County, California, you'll discover a unique habitat known as coastal scrub. A multitude of shrubs and low-growing plants grow there, including wax myrtle, monkey flowers, California sagebrush, California bay laurel, coyote bush, and native bunchgrasses. But you won't find many trees—just the occasional coast live oak or willow. All of those plants have adapted to the region's Mediterranean climate, where six months of wet cool weather are typically followed by six months of hot drought.

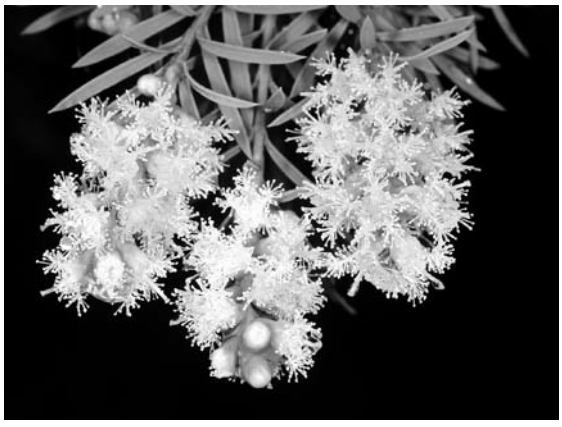
Many birds perch on and fly among the coastal scrub, including golden-crowned kinglets, white-crowned sparrows, golden-crowned sparrows, and Bewick's wrens. Rufous-crowned sparrows, vireos, kinglets, and wood warblers forage for insects in the green leaves of live oaks and wax myrtles. Bay checkerspot butterfly larvae feed on narrow-leaved plantain. Nearby streams are home to threatened coho salmon and steelhead, which support important fisheries. Rare northern spotted owls nest in nearby forests. In addition, many shorebirds move up local creeks when high tide covers their favored mud flats.

NEW ARRIVAL

In the 1850s, people began planting eucalyptus trees from Australia throughout coastal and central California. The trees grew extremely fast in the United States. They were deemed the perfect source of timber and fuel, replacing the redwood forests that had been clearcut.

Eucalyptus trees survive by sending long roots down and out through the soil. In the process, though, they can clog drains and damage streamsides. In addition, the trees blow over easily in the wind, bringing down more soil in the process. Most eucalyptus trees are filled with combustible resin and have long shredding bark. They produce great quantities of litter—fallen leaves, bark, and so forth—which in their native habitat was broken down by microbes and insects. To ensure that few other plants compete with them, eucalyptus trees also produce their own herbicide that kills many young plants beneath them.

Each winter, eucalyptus trees produce flowers that attract insects and, with them, insect-eating birds. But the flowers of the tree are filled with a sticky gum. In Australia, birds such as Australian honeyeaters and leaf gleaners have evolved long bills that enable them to reach into the flowers without getting the sticky gum all over their bills and faces.



Hawaiian Islands

If you've taken a close look at a world map, you know that the islands of Hawaii are isolated from the nearest mainland by huge distances—more than 2,500 miles. That's one of the main reasons for the tremendous number of species in Hawaii that are found there and nowhere else. Too far away to interbreed with populations on other continents, the species of Hawaii evolved over time in completely unique ways. One species of finch, possibly a Eurasian rosefinch, colonized the islands and eventually evolved into 54 separate species of Hawaiian honeycreepers!

Hawaii's birds did not evolve with any particular adaptation to predators because the islands had few. There were no snakes, no foxes, no raccoons, and no wild cats. There were only two birds of prey: the 'io (hawk) and pueo (owl). Many birds were flightless. Many birds, such as the nene goose, Hawaiian black-rumped petrels, and Newel's shearwaters, built their nests on the ground.

Hawaii's original list of native species included only two mammals: a bat and a seal. Reptiles, amphibians, insects, and other invertebrates abounded. In fact, the islands' tree snails are among the most prized native species.

NEW ARRIVAL

By the 1880s, the Hawaiian landscape had already changed considerably. Early Polynesian settlers—and later waves of Europeans—cut down native forests and introduced grazing animals and poultry. They also began cultivating sugar cane and other crops. But those crops were under attack by accidentally introduced Norway and black rats that had stowed away on ships. Because Hawaii had no predators, the rat populations threatened to grow out of control. So, settlers decided to introduce the small Indian mongoose, a weasel-like animal that is known to eat rats. The Indian mongoose is native from Iran, and traveled through India to Myanmar and the Malay Peninsula.

Small Indian Mongoose. Photo by Rick Taylor, 2/1/06. ©Borderland Tours.

Mongooses are small, slender animals with brown fur and a bushy tail. They breed two or three times a year, producing litters of three young. Females can begin breeding at the age of 10 weeks. Mongooses live in burrows and can adapt to a variety of settings. They feed on a wide variety of small vertebrates, including small mammals, snakes, iguanas, birds, eggs and young of larger vertebrates (for example, sea turtle eggs), large invertebrates, and on occasion, fruits and vegetables.

Florida Everglades

If you've spent any time in the Florida Everglades, you've seen an exceptionally rare and rich habitat. The Florida Everglades is North America's only flooded grassland, a "river of grass" that flows from the Kissimmee River south to the Florida Bay. Along the way, the water fills deep areas called sloughs, surrounds hardwood-covered islands called hammocks, and trickles past the roots of mangrove trees clinging to the shore.

Those varied habitats provide home to a wealth of creatures, many of them found nowhere else on Earth. The United States' only population of Florida panthers—numbering only about 60—ekes out a life by hiding in remote areas and feeding on deer, raccoons, and other animals. Flocks of wading birds rely on small fish and invertebrates for their food. Large fish prey on those smaller fish. Alligators cruise the waters in search of a meal of large fish, birds, or other easy prey. Large birds called snail kites fly overhead keeping an eye out for their one and only food: Florida apple snails.

All of those species have been hard hit by habitat loss in the Everglades, by drastic alterations to the natural flow by human communities, and by pollution. Panthers, wading birds, snail kites, and many other species are threatened or endangered. But new efforts are underway to restore some of the region's water flow, which could help the rare species bounce back and could lead to cleaner water resources for wildlife and people alike.

NEW ARRIVAL

In the mid-1990s, scientists were surprised to discover a strange creature inhabiting waterways in Georgia and Florida: the Asian swamp eel. Swamp eels grow to lengths of up to three feet, and they eat crayfish, shrimp, worms, frogs, tadpoles, and other fishes.

In their native region, swamp eels are commonly caught and sold for food, but in the United States, they have no known predators. They are native to Central and South America, Africa, and Australia, and extend from India to eastern Asia, including much of China.

Asian swamp eels have many adaptations to help them survive in the United States. They can live in everything from ponds to marshes to roadside ditches. They are highly secretive, with most of their activities occurring at night. Because they are air breathers, they can even survive on and travel across land to other bodies of water. The Asian swamp eel can survive weeks without food.

Asian swamp eels have been spotted within a mile of Everglades National Park.

Chicago Hardwood Forests

If you walk down the streets of Chicago's city neighborhoods, you'll be impressed by the number and size of large street trees. Among the most common trees are ash, cherry, elms, maples, elms, mulberry, oak, and plum.

You may not normally equate city trees with a forest, but that's what they form: an urban forest that makes cities cleaner, more attractive, and more wild. Chicago's urban forest is a rich habitat for wildlife, providing food and shelter for migrating and resident birds, squirrels, raccoons, opossums, and a host of insect species. The trees provide shade for residents and reduce cooling costs during the summer when they block sun from houses and businesses. They absorb pollutants from automobiles, making the air much healthier to breathe. In fact, scientists recently calculated that city trees in places such as Chicago play a major role in absorbing carbon dioxide that would otherwise reach the atmosphere and contribute to global warming (see source below).

Urban trees are so important to the city of Chicago that experts have estimated their value at about half a billion dollars. And that figure does not even include the hard-to-quantify benefits such as improved appearance, resident quality of life, and long-term climate improvement.

NEW ARRIVAL

In 1998, Chicago residents discovered unusual insects living on city trees: Asian longhorned beetles from China. Just two years before, Asian longhorned beetles had been found in two New York sites. Asian longhorned beetles are about 3/4 to 1 1/2 inches long. They feed on a variety of hardwood trees, especially ash, birches, buckeyes, elms, horsechestnuts, maples, poplars, sycamores, and willows.

Their life cycle begins when a female beetle chews her way through the bark of a host tree and deposits her eggs. Eleven days later, the larvae emerge from their eggs and begin to feed on the living tissue of the tree's xylem and phloem. These are the tree's pathways for carrying water from the tree roots up the tree and taking nutrients from the leafy canopy down, respectively. Once the pathways have been disrupted, the tree will no longer be able to circulate the water and nutrients it needs to survive. After reaching lengths of approximately two inches, the larvae enter the pupal stage. When the adults emerge from the pupa, they bore their way out of the trunk, leaving round exit holes that are just a bit larger than the diameter of a pencil.

Asian longhorned beetles live about one year and usually spread by natural means—flying about 400 yards or more in their beetle stage.

Nowak, D. J. "Atmospheric Carbon Dioxide Reduction by Chicago's Urban Forest." In E. G. McPherson, D. J. Nowak, and R. A. Rowntree, (eds.). *Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. USDA Forest Service General Technical Report* NE-186. Radnor, PA: USDA, 1994, 83–94. cufr.ucdavis.edu/products/cufr_189_gtr186b.pdf.

Sagebrush Shrub Steppe

When early settlers traveled the intermountain west, they traveled through mile after mile of sagebrush habitat. More than 12 species of sagebrush grow from British Columbia to Baja California, reaching their greatest concentration in the Great Basin region of Nevada, western Utah, southern Oregon and Idaho, and a small part of eastern California. The hardy plant survives where many others can't by using its deep roots to tap into water and nutrients and by accomplishing photosynthesis even under very low levels of light.

Where sagebrush grows strong, it's something like a community center, providing food, shelter, and even dance space to residents who need it. A total of about 100 bird species, 70 mammals, and 23 amphibians and reptiles depend on sagebrush to some degree, but some are extremely dependent. Pronghorn, for example, rely on sagebrush for about 90 percent of the food they eat. Sage grouse, sage sparrow, sagebrush lizard, and sagebrush vole rely on eating sagebrush and the grasses that grow around it. Sage sparrows and Brewer's sparrows build their nests in sagebrush. Mule deer hide their fawns in the brush. Sage grouse also find shelter from wind, snow, and sun in sagebrush areas. What's more, the spare ground around sagebrush bushes provides the perfect spot for male sage grouses to perform their annual mating dances.

The value of sagebrush extends beyond the species that rely directly on it. Predator species, such as raptors, are drawn to the diversity of small mammals and birds that inhabit sagebrush areas. Where it grows, sagebrush also plays an important ecological function by stabilizing soils and preventing erosion.

Sagebrush in Wyoming, photo by Bureau of Land Management Wyoming

NEW ARRIVAL

Cheatgrass, also known as Downy Brome, is native to the Mediterranean region and was introduced in the United States. in packing materials and, perhaps, as a seed contaminant, in the 1800s. This plant is hardy and grows rapidly, particularly on land that has been disturbed by cattle grazing, farming, or other uses.

The plant is unpalatable and may injure livestock because it forms sharp-edged seed clusters. Cheatgrass also is highly flammable. This plant now affects more than 100 million acres in the United States.

Sources:
Lipske, Michael. "America's Forgotten Ecosystem." *National Wildlife*, (October/November 2000).
Cox, George W. *Alien Species in North America and Hawaii: Impacts on Natural Ecosystems*. Washington, DC: Island Press, 1999.

Atlantic Coastal Estuaries

Up and down the Atlantic Coast, oysters, clams, crabs, and mussels thrive in rich marine habitats called estuaries. Estuaries form where rivers empty out into saltwater bays, creating a mixture of freshwater and saltwater. You will often find them surrounding coastal salt marshes. Wherever they occur, estuaries support a tremendous diversity of marine life—including a lot of popular seafood.

Rich in nutrients and sheltered from big waves, estuaries provide the perfect conditions for many aquatic species to begin their lives. The juvenile Atlantic stingray, summer flounder, bluefish, white perch, striped bass, and other coastal fish spend part of their lives feeding and reproducing in estuary waters. Blue crabs carry out their entire life cycle in and near estuary waters. Scallops, softshell clams, and oysters breed and feed in the brackish waters. Those species, in turn, provide food for many shorebirds including American oystercatchers, gulls, terns, herons, and more.

The Chesapeake Bay, located between Maryland, Virginia, and Delaware, is the largest estuary in the United States. The Chesapeake Bay is one of many Atlantic Coastal estuaries that supplies us with seafood. In fact, more than 60 percent of the edible seafood in the United States comes from coastal estuaries.

NEW ARRIVAL

Scientists estimate that the first European green crabs arrived on the Atlantic Coast more than 150 years ago. Those crabs, originally from Europe, probably arrived in the ballast water of ships. Ships take on ballast water in port after emptying cargo. The water helps the ships stay stable for their next journey. Unfortunately, that ballast water is full of aquatic species from the original port. When the ships discharge the ballast water in their next port, the species are discharged, too.

Young green crabs do best in coastal ponds, lagoons, and bays. They are voracious eaters, consuming mussels, clams, snails, other crabs, barnacles, aquatic worms, and green algae. They can't easily crush a hard clam shell, but they can dig out soft clams from the clams' burrows that are six inches deep. Under the right conditions, female green crabs can spawn up to 185,000 eggs at a time.

Understanding Invaders Worksheet

1. Describe the original ecosystem (before the arrival of the new species).

2. Using the information provided, draw a diagram showing the web of relationships in the original ecosystem (for example, predator/prey relations, ways animals depend on plant habitat, ways people depend on wild species, etc.)

3. Are there any plants or animals in the original ecosystem that seem particularly important? Explain.

4. What is the nonnative species described on your handout.

5. Where did it come from, and how did it get to the ecosystem?

6. Make some predictions about how this new species might affect the ecosystem. What changes might occur? What benefits might come of those changes? What problems? Be sure to provide a justification for your ideas.

Useful Websites on Invasive Species

California Academy of Sciences
www.calacademy.org/science_now/—The California Academy of Sciences' website has a Science Now section that presents a changing display of current issues and research being done in California.

Invasive Species Specialist Group
www.issg.org—This website lists the top 100 invasive species around the world and provides a global invasive species database.

The Nature Conservancy
tncweeds.ucdavis.edu/products/gallery/regionlist.html—This website provides information on The Nature Conservancy's Global Invasive Species Initiative. It includes resources designed to help conservationists deal with invasive species.

Union of Concerned Scientists
www.ucsusa.org/invasive_species/—The Union of Concerned Scientists' website provides information on invasive species, on what individuals can do to help prevent species invasions, and on links for additional information about invasive species.

U.S. Bureau of Land Management
www.blm.gov/education/LearningLandscapes/explorers/lifetime/invasive.html—This website hosted by the U.S. Bureau of Land Management provides useful links for information about invasive species, as well as state and field office resources.

USDA Forest Service
www.fs.fed.us—This website is the home page for the Forest Service. It includes information on regional offices, as well as information and links on invasive species.

USDA National Agricultural Library
www.invasivespeciesinfo.gov—This website provides information about invasive species and serves as a reference gateway to information, programs, organizations, and services about invasive species. It includes information about the effects of invasive species and the federal government's response, as well as select species profiles.

World Wildlife Fund
www.worldwildlife.org—This website is for the World Wildlife Fund. Use the search button to find information on specific invasive species and articles on invasives.

Nonnative Controversy: Swan Song

Almost everyone agrees that mute swans are majestic, beautiful birds. What they don't agree on is whether mute swans belong on New England lakes. Mute swans were introduced to this country from Europe in the 1800s. Since then, they've spread throughout the mid-Atlantic and New England region. Now biologists say that the invasive birds are damaging to wetlands. They say the swans force out native water birds, making it impossible for the native birds to nest and reproduce.

In Vermont, **wildlife managers** concerned about the effects of mute swans recently began shooting and killing mute swans on their lakes after other control methods didn't work. **Local residents** were furious, especially because the shootings were unannounced, and because they happened right in front of the residents.

What to Do

The main characters in your scenario are shown in bold type. Use them and any others characters you come up with to act out a situation depicting the conflict over mute swans on Vermont's lakes.

Sources

Allin, Charles C. "Mute Swan (Cygnus olor) impact on submerged aquatic vegetation and macroinvertebrates in a Rhode Island coastal pond." Northeastern Naturalist. 2003. www.dem.ri.gov/programs/bnatres/fishwild/pdf/muteswan.pdf (accessed December 26, 2006).

Atlantic Flyway Council. "Atlantic Flyway Mute Swan Management Plan, 2003–2013." July 2003. www.dnr.state.md.us/wildlife/afcmuteplan.html (accessed December 26, 2006).

Olsen, Stephen and Eleanor Ely. "Rhode Island's Swans: Beauties or Beasts?" Sea Grant, Rhode Island: 1988. www.seagrant.gso.uri.edu/factsheets/ri_swans.html (accessed December 26, 2006).

Nonnative Controversy: Marina Mussels

When divers explored a marina off the Australian town of Darwin, they saw something they knew didn't belong: tiny mussels related to the zebra mussel that have clogged up North America's Great Lakes. Hundreds of millions of those mussels were clinging to piers and boat hulls and lines where there had been none just six months earlier. The divers, who were part of an inspection team from a scientific agency, identified the mussels as coming from Central America. They believed the mussels had arrived on the hull of a yacht. Within a week, **government officials** took drastic action. First, they refused to let any boats in the area leave port, despite the objections of **boat owners**. Then they poisoned the waters of the marina with chlorine and copper. The poison killed all the mussels, but it also killed everything else that lived in the marina. Now, though, the native species are coming back and the Central American mussels haven't returned. But was it worth the $1.5 million price? What happens if the mussels show up again? And is it ecologically acceptable to poison natural areas and to kill off so much life? These issues have yet to be resolved.

What to Do

The main characters in your scenario are shown in bold type. Use them and any other characters you come up with to portray some of the conflicts and complexities involved in getting the Central American mussels out of the Darwin marina.

Sources

CSIRO's Centre for Research on Introduced Marine Pests. "The Facts: Black-Striped Mussel." Australia's Commonwealth Scientific and Research Organization: 2004. www.marine.csiro.au/LeafletsFolder/blstriped.html (accessed December 26, 2006).

Zebra mussels

Nonnative Controversy: Discord Over Cordgrass

The Willapa Bay region of Washington state is one of the most productive coastal areas in the world. Oyster, clam, and salmon fisheries are a huge part of the economy. Thousands of birds come here to feed and nest. Unfortunately, the health of this region is threatened by several invasive species, including *Spartina*, or cordgrass. *Spartina* was brought to the region in the 1800s as packing material for eastern oysters, which were introduced to revive the oyster industry after native oysters were harvested to near extinction. Unfortunately, the *Spartina* has grown out of control in its new home, reducing the habitat for native crabs, snails, salmon, shorebirds, and other organisms.

Not surprisingly, people are working hard to get rid of *Spartina* to protect the ecosystem and the economy. They've tried mowing and hand-plucking the cordgrass, and some people are advocating that a *Spartina*-eating insect be introduced to the area. But so far the most cost-efficient control method seems to be an herbicide that, when dumped into the water, kills off much of the grass. Many people involved in the **oyster industry** favor this control method. But others do not.

Members of the **Shoalwater Bay Indian Tribe**, which has a reservation on the edge of the bay, have complained. They don't think it makes sense to put a poison in the water, because it can be absorbed by other living things in the bay. They're especially concerned because members of their tribe have been having serious health problems. In one recent period, for example, 18 of 27 pregnancies ended in miscarriage. Because they think those health problems may be tied to the use of chemical herbicides, the Shoalwater Bay Indians and other concerned individuals think that people should investigate new ways of controlling *Spartina*. The Indians point out that some **industries** mow and hand-cut the *Spartina* and make it into paper and other products. This method wouldn't get rid of the grass as cheaply or quickly as herbicides, but it might be much better for people and the ecosystem over the long run.

What to Do

The main characters in your scenario are shown in bold type. Use them and any other characters you come up with to portray the conflict over controlling *Spartina* grass in Willapa Bay.

Sources

Murphy, Kyle C., Randall R. Taylor, and Chad H. Phillips. "Spartina Eradication." Washington State Department of Agriculture (WSDA): 2007. agr.wa.gov/PlantsInsects/Weeds/Spartina/default.htm (accessed December 26, 2006).

Murphy, Kyle, Brad White, and John Lundberg. "Historical Reduction of Spartina Grass Occurs in Willapa Bay." WSDA: 2005. agr.wa.gov/News/2005/05-27.htm (accessed December 26, 2006).

Riggs, Sharon. "The Cordgrass Is Not Always Greener on the Other Side." Environmental Protection Agency: 1999. http://www.epa.gov/owow/estuaries/coastlines/99oct.pdf (accessed December 26, 2006).

Spartina

How to Prevent Invasive Species

Here are some ways to help stop the introduction and spread of harmful invasive species in your community:

Gardening
- Avoid growing plants known to be invasive.
- Be cautious when buying plants from nurseries or seeds from other regions of the country.
- Avoid using seed mixtures, especially ones labeled "wildflowers."
- Landscape with plants native to your area.
- Never dispose of unwanted plants or garden clippings in a nearby park, local body of water, or natural area.

Boating and Fishing
- Never transport water, animals, or plants from one body of water to another.
- Do not release live fish, including bait, into a new body of water.
- Remove all aquatic plants and animals from hulls, propellers, intakes, trailers, and gear before leaving a launch area.
- Wash all fishing tackle, downriggers, and lines to prevent spreading small, larval forms of aquatic invaders.

Pets
- Buy any legal, nonnative pets only from reputable dealers.
- Don't release any pets or aquarium fish into a native habitat or natural body of water.
- Purchase certified weed free hay for horses.

Traveling
- Never carry fruit, seeds, live plants, soil, or animals into or out of the country.
- Within the country, don't transport items such as hay, wood, soil, sod, or gravel from one part to another.
- Wash your boots and tires to remove soil and weed seeds before you hike in a new area.
- Abide by local and international quarantines to prevent the spread of serious pests, weeds, and diseases.

Take Action!
- Tell others about the harm that invasive species can cause.
- If local nurseries sell invasive plants or seeds, let them know your concerns.
- Volunteer to help remove invasive plants from your local park or nature reserve.
- Learn to recognize common invaders and to keep an eye out for signs of new ones. Check trees, gardens, vacant lots, roadsides, yards, agricultural areas, wetlands, ponds, and lakes.
- If you think you have found a new infestation, contact your county agricultural agent or state Department of Natural Resources. Early detection is crucial to stopping an invasive from becoming permanently established!

Adapted with permission from "What You Can Do to Prevent Species Invasion." Union of Concerned Scientists. www.ucsusa.org/invasive_species/what-you-can-do-to-prevent-species-invasion.html (accessed December 13, 2006).

Content Questions

1. What is a nonnative species?

2. What is an invasive species?

3. How have people and their activities caused nonnative species to spread to new environments?

4. What are some of the different ways that invasive species affect our environment?

5. What are scientists doing to control invasive species?

6. What things can individuals do to limit the spread of invasive species?

7. How does the problem of invasive species compare to with environmental problems?

2 Protected Areas: Issues and Analysis

By analyzing case studies and describing some of the challenges and conflicts, students will learn about the importance to biodiversity of protected areas.

Level
Grades 9-12

Subjects
Biology, Debate, Environmental Studies, Geography, Social Studies

Concepts
1.2; 2.10; 3.8; 3.9; 3.10; 4.9; 5.11. See the Conceptual Framework for a complete description of the concepts.

Skills
Analyzing, Comparing and Contrasting, Defining Problems, Discussing, Reasoning, Reporting

Materials
Copies of the student pages. If possible, access to the Internet and to word processing or presentation software.

Time Considerations
Part A: Two 50-minute periods
Part B: Four 50-minute periods

Related Activities in Other PLT Guides
PreK-8 Guide: Planet Diversity; Charting Diversity; Viewpoints on the Line; Web of Life; Planning the Ideal Community; Life on the Edge.

Focus on Risk module: Weighing the Options: A Look at Tradeoffs.

Focus on Forests module: Case Study: Old Growth Forests; Tough Choices; Balancing America's Forests.

Forest Ecology module: Adopt-a-Forest.

Places We Live module: Personal Places; Community Character; Green Space; A Vision for the Future.

Objectives
- Students will be able to provide a definition of protected area.
- Students will be able to describe several different kinds of protected areas and to explain how they differ.
- Students will understand some of the issues and conflicts surrounding management of protected areas.
- Students will learn how to analyze a conflict, thereby naming the parties, their interests, their beliefs, and their values.

Assessment Opportunities
- Use class presentations by students and "Analyzing the Issue" student pages to assess their understanding of the challenges and conflicts surrounding protected areas.
- Have students cut out an article from a recent newspaper or magazine (or find one on the Internet) about a conflict in a protected area. Then have them write down a few thoughts about the conflict on an index card and bring both items to class for a "Current Protected Areas Conflicts" bulletin board.
- Have students cut out an article from a recent newspaper or magazine (or find one on the Internet) about a conflict in a protected area. Then have them write a brief essay about the topic presented in the article. Rather than simply summarizing the conflict and its players, have students use this assignment as a chance to think more about their own ideas for resolving conflicts about protected areas.

Background

What do biosphere reserves, city parks, national forests, national wildlife refuges, and state parks have in common? They are all areas that have been given some level of protection to help conserve the natural and cultural assets of the area. Each area receives different levels of protection based on the management objectives for that area. For example, national forests are managed to provide recreational value and wildlife habitat value, but also to provide for natural resource harvesting (timber, minerals, etc.). Alternatively, most national parks and wildlife refuges are managed solely for conservation and recreational use and rarely allow natural resource extraction. While each protected area may be managed somewhat differently, they all play critical roles in maintaining biodiversity.

You and your students have probably already had an opportunity to enjoy the benefits of a protected area. Maybe you have spent a summer weekend at a national seashore. Or you've enjoyed a picnic in a city

Jasper National Park, Canada

park. Or you've taken a trip to Yellowstone or Yosemite National Park. Many people enjoy protected areas because they offer great opportunities for recreation and relaxation. And many people appreciate knowing that protected areas provide habitat for wild species in a human-dominated world. But anyone who has paid close attention to protected areas at the local or national level knows that managing them is no easy task. After all, many protected areas (such as national forests and national parks) are owned collectively by the public—a public that represents a diverse set of values and preferences. Thus, when an issue—such as whether or not to allow snowmobiling in Yellowstone National Park—comes up, people will assert very different preferences. Decision makers and managers have to decide how best to resolve the conflicts among competing interest groups.

Also, despite the fact that protected areas generally have clear boundaries—at least on paper—it is impossible to completely set them apart from the communities that surround them. For example, neighboring populations may not know or heed protected area boundaries, and people may carry out uses in them for which they were not intended. Pollution from nearby smokestacks, roads, or rivers may degrade them. Nonnative species may invade, thereby dramatically changing a protected area's species composition. What's more, many of the wild species in a protected area range beyond its borders, limiting the protection it affords. For such reasons, managing a protected area is complicated business, raising all sorts of challenging questions for those trying to care for the area and its inhabitants.

This activity will introduce your students to some of those thought-provoking issues, and will present a total of six case studies about different protected areas around the world. In all but the first case study (a national policy issue that will be read together as a class), students will learn about the history of a specific protected area, its special characteristics, and a conflict that has arisen over it. Accompanying text and quotes will present the divergent views of people from different interest groups.

Your students will have the job of sorting through the conflict and analyzing who's involved and what's at stake. In so doing, your students will increase their knowledge of protected areas and the various services that those areas provide for humans, wild species, and biodiversity. At the same time, they will develop critical skills in conflict analysis.

Being adept at conflict analysis can equip your students with skills that will help them to sort through controversies that arise in any aspect of their lives, from personal relationships to the global political arena. Your students will become more discriminating readers and listeners—better able to understand the ways people may display bias in what they say and do. The students should also begin to see the relationship between people's positions and their core beliefs, thus gaining more respect and empathy for people with opinions different from their own.

Throughout this case study, we encourage you to help your students find ways of speaking and interacting that show respect for other people and their views. The skills your students will develop may help them not only analyze conflicts in their lives, but also move toward resolving them.

Getting Ready

Part A

Copy the student pages titled "A Road through the Trees," "Analyzing the Issue," and "Protected Area Definitions" for each student. Make several copies

of the student page titled "Forest Quotes," and cut apart the quotes (you will probably need four or five copies of each quote). Make copies of "The Components of an Environmental Issue" student page for each student (optional).

Part B

Make enough copies of each of the protected area case study student pages so that all students in each of the five groups have a copy of their case study. Make enough copies of "Analyzing the Issue" student page so that each team has a copy.

Doing the Activity

Part A: Defining and Analyzing Protected Areas

1. Ask students if they have ever thought about what a protected area is. What comes to mind when they hear it? Have the students generate a quick list of different kinds of protected areas. You can add to the list if you think that the students did not come up with enough ideas. Review the definitions for different protected areas using the student page titled "Protected Areas Definitions." Then explain to them that the case studies in this unit will focus on different kinds of protected areas around the world and on some of the challenges those areas face.

2. Ask for one or two volunteers to read out loud the information on this student page. Tell the students that the issue of roads and forests still is not resolved, but this material gives them a sense of the basic conflict and the perspectives of some of the major parties when the issue heated up around 1999–2000. You can answer any questions that the students might have, but do not jump into a discussion of the information just yet. Instead, tell the students that they are going to divide into teams, and each team member will assume a different role of someone interested in the outcome of the nation's roadless areas policy.

3. Once the class is divided into separate teams, pass out copies of the cut-apart quotes on the "Forest Quotes" student page so that each person on the team has a different quote. Have the students read the quotes to themselves, and then have them take turns explaining "their" point of view to the rest of the team. After the students have shared their assigned point of view, have them think about the different viewpoints they heard. Which ones were similar? Which ones were extremely different? Have each team find a way to organize or represent the general sides to this conflict. For example, they might arrange themselves in a way that groups individuals with similar opinions. Or they might draw a diagram showing both separate and overlapping points of view.

4. Ask for a spokesperson from each group to explain to the rest of the class the creative way that the group chose to describe the situation. Compare the different representations. Were they similar? Why or why not?

5. Pass out copies of the student page titled "Analyzing the Issue." Using the information that follows, explain what each one of the terms means. You may choose to pass out copies of the student page titled "The Components of an Environmental Issue" for students to have as a reference. As a class, fill out the "Analyzing the Issue" page using the case study concerning road building in national forests. (Or if you prefer, you can assign it for homework and then review the students' answers in the next class.) Suggested answers are provided.

Explain that the conflict over roadless areas in national forests is like any conflict in that it has the following elements:

a) **A problem.** What's the basic problem that started this conflict?

> *Answer: People are concerned about the effects of roads and timber-cutting in the wilderness areas of our national forests.*

b) **An issue.** Explain that an issue differs from a problem when people disagree about how to address the problem. What's the issue in this example?

Answer: The issue is whether or not to continue building roads in the remaining roadless areas of our national forests.

c) **Parties.** Parties, or players, are the different individuals or groups with distinct points of view about the issue. Who are the parties in this conflict?

Answer: Dan Glickman, former secretary of the U.S. Department of Agriculture (USDA); Helen Chenoweth, former Republican representative from Idaho; Clark Chappell of the Southern Utah Forest Products Association; Carl Pope of the Sierra Club; Mike Dombeck, former chief of the U.S. Forest Service (which is part of the USDA); Henson Moore, former president and CEO of American Forest & Paper Association (AF&PA); former U.S. President, Bill Clinton; Mike Moser from the Boise Cascade timber company; and Carla Boucher, an attorney for the United Four Wheel Drive Associations.

d) **Interests.** What does each party want?

Answer: AF&PA, the United Four Wheel Drive Associations, and Helen Chenoweth are opposed to limits on roads and timber-cutting in national forests; Dombeck, Glickman, and small Utah timber companies want limits set on road-building but sustainable harvesting of trees; the former President wants to fully protect all remaining roadless areas larger than 1,000 acres; the Sierra Club wants no more timber-cutting on national forests at all; and Boise Cascade is in favor of some level of harvesting.

To what extent do those parties' interests overlap?

Answer: Refer to the student representations of the conflict from Steps 3 and 4. You might point out that the Forest Service is part of the USDA, which is why those viewpoints overlap.

Are there limits to what you can deduce according to these quotes alone?

Answer: Many people mention issues that others do not refer to, so it's unclear, for example, whether or not the Forest Service of USDA would agree with the former President that remaining roadless areas should be fully protected.

e) **Beliefs.** What are the basic beliefs that influence each of the parties' interests?

Answer: AF&PA and Helen Chenoweth believe national forests were created to meet U.S. timber and paper needs, to provide jobs, and to provide recreational opportunities or access for the public. Similarly, Boise Cascade believes that timber-cutting in the roadless area will benefit both the people and the forest. The United Four Wheel Drive Associations believe that the current protection laws are sufficient. Utah timber cutters and the Forest Service of USDA believe that forests should balance timber needs with environmental protection. Former President Clinton and the Sierra Club believe that additional roads and timber-cutting would degrade the remaining roadless areas. It is not clear whether Utah timber cutters and the Forest Service of USDA would share that opinion.

f) **Values.** Explain to the students that values are at the very core of people's beliefs. For example, a person who believes that all people should have equal access to good schools may value social fairness and education. What are the values of the parties in this conflict?

Answer: AF&PA, Helen Chenoweth, and the United Four Wheel Drive Associations value the economic and recreational benefits of national forests. Sierra Club and the former President express a strong value for healthy ecosystems and biodiversity. The Forest Service of USDA and Boise Cascade care about balancing both of those things. Utah timber cutters value long-term economic health of their families and communities.

Do people with similar positions always hold the same values?

Answer: No. One group may want to limit roads, for example, to protect wildlife; another may want to preserve a wilderness experience for people who hike there.

Why might it be easier to try to change people's positions in a conflict than to change their values?

Answer: Values are the most fundamental underlying basis for people's beliefs and positions; values are very close to the identity of the parties. Therefore, they are not very likely to change, at least not quickly.

g) **Solutions.** Can the students think of any ways that one could resolve such a conflict?

Part B: Protected Area Case Studies

1. Explain to the students that national forests are not the only protected areas where a conflict has occurred. To better develop their understanding of protected areas and to hone their skills at conflict analysis, the students will explore issues about management in five different places that are in protected areas.

Divide the class into five teams. Give the members of each team an individual copy of the student page for their assigned protected area:

- Protected Area #1: Galápagos Islands, Ecuador
- Protected Area #2: Pelekunu Preserve, Hawaii
- Protected Area #3: Blockhouse Point Conservation Park, Maryland
- Protected Area #4: Katmai National Park, Alaska
- Protected Area #5: Florida Everglades, Florida

2. Tell the students that they are responsible for reading their protected area handout as homework. In class the following day, they will meet as a group to fill out the "Analyzing the Issue" student page for their protected area. Then they will spend the rest of that class period and all of the next class period preparing a creative presentation to introduce other members of the class to this particular area and the issue.

Tell the students that they should think of interesting and engaging ways to present their conflict. Have them think about some of the different formats for conveying multiple sides of an issue, such as debates, town meetings, talk shows, and so on. Most students should be familiar with formats that encourage players to defend their side until the disagreement escalates into an argument. Can they think of more constructive ways to get people talking about difficult issues? Can they portray both the tension and a constructive resolution with their own issue?

3. Students should read and discuss their case studies within their teams, filling out the "Analyzing the Issue" worksheet. They should discuss their presentations, agree on a creative format, and then begin preparations for their presentation. Remind the students that their presentations should (1) make it clear what the issue is about, (2) describe where the protected area is located, and (3) address all of the items on the "Analyzing the Issue" student page. Tell them to aim for a 10-minute presentation.

4. Have the students finish preparing for their presentations. You might circulate among the groups to hear some of their ideas and to give them pointers. Ask each group what equipment they will need for their presentation (easel, overhead projector, poster board, props, and so on), and decide together how to get that equipment to class.

5. Select the order of the presentations. Depending on the length of your class, you may want to time the students and to limit their presentations to 10 minutes, with five additional minutes for discussion afterward. After each one, you might ask the rest of the class to summarize the basic conflict they observed and to share any responses. (You may want to hand out enough copies of the

"Analyzing the Issue" student page so that students who are listening to the presentations can fill it out for each protected area.)

6. After the group presentations, discuss the following issues:

- After preparing your own presentation and listening to the other presentations, did your opinion change about what a protected area is? How would you define a protected area now? What do you think the benefits are to people who live near protected areas? What do you think the benefits are to biodiversity?
- Why do you think it is common for there to be issues over the use of protected areas?
- What is the role of values in issues about protected areas?
- How often did you notice that the parties in a conflict seemed to have more agreement than they acknowledged? Why does this anomaly happen in a conflict? How can it be addressed?
- What strategies did you observe or think about as ways of resolving conflicts in the protected areas?
- Have you heard about any recent conflicts about protected areas in your region? The state? The nation? Describe one of those conflicts for the rest of the group. How do your experiences with this case study affect your thoughts about such conflicts?

Enrichment

Is there an issue surrounding a protected area in your community? Have the class find out more about the issue. Take a field trip to visit the site. Have the students interview different players. Then have them come up with a group project that they think might be helpful in this issue—for example, a public education program, a student-led mediation, a town meeting, and so forth.

Protected Area Definitions

Tatra Biosphere Reserve, Poland

Biosphere Reserve: Areas of terrestrial and coastal or marine ecosystems that are internationally recognized as promoting and demonstrating a balanced relationship between people and nature. Biosphere reserves are much like laboratories where new and best practices to manage nature and human activities are tested and demonstrated. Examples include Haleakala and Hawaii Volcanoes National Parks in the U.S. and Tatra in Poland and Slovakia.

Source: United Nations Educational, Scientific, and Cultural Organization (UNESCO). "Biosphere Reserves: Reconciling the Conservation of Biodiversity with Economic Development." http://www.unesco.org/mab/BRs.shtml (accessed on December 21, 2006).

Shenandoah National Park, Virginia

National Park (U.S.): An area of particular natural, cultural, historic, or recreation value that is under the jurisdiction of the National Park Service. It includes national parks, national monuments, national historic sites, and so forth. According to a congressional act, the National Park Service shall promote and regulate those areas "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." Examples include Yellowstone and Rocky Mountain National Parks.

Source: National Park Service. "The National Park System: Caring for the American Legacy." http://www.nps.gov/legacy/ mission.html (accessed on December 21, 2006).

Wading Birds at a Wildlife Refuge

National Wildlife Refuge (U.S.): Areas protected by the federal government through the U.S. Fish & Wildlife Service (USFWS). "The National Wildlife Refuge System is a network of habitats that benefit wildlife, provide unparalleled outdoor experiences for all Americans, and protect a healthy environment. Refuges are special places where the USFWS and its partners restore, protect, and manage habitat for America's wildlife." An example is the Arctic National Wildlife Refuge.

Source: U.S. Fish & Wildlife Service. "America's National Wildlife Refuges."http://www.fws.gov/refuges/generalInterest/factSheets/FactSheetAmNationalWild.pdf (accessed on May 2, 2007)

Chiricahua Wilderness Area, Arizona

National Wilderness Area (U.S.): "[A]reas of undeveloped federal land that retain their

Protected Area Definitions (continued)

primeval character and influence, without permanent improvements or human habitation, which are protected and managed to preserve their natural conditions. These areas are established as part of the National Wilderness Preservation System according to the Wilderness Act of 1964. P.L. 88-577." Examples include the Petrified Forest National Wilderness and Sawtooth National Wilderness areas.

Source: NationalAtlas.gov. "National Wilderness Preservation System of the United States." http://nationalatlas.gov/mld/wildrnp.html (accessed on December 21, 2006).

Bighorn National Forest, Wyoming

National Forest: Federally owned reserve administered by the U.S. Forest Service, which is part of the U.S. Department of Agriculture. By law, the national forests must be managed for multiple uses, such as forest products, recreation, watershed protection, wilderness, livestock grazing, mineral extraction, and wildlife habitat. Examples of National Forests include the Chattahoochee National Forest and Bighorn National Forest.

Source: American Forest Foundation. Project Learning Tree's Secondary Environmental Education Program titled "Exploring Environmental Issues: Focus on Forests." Washington, DC. 1998.

Greenway Bike Path

Greenway: A linear open space; a corridor composed of natural vegetation. Greenways can be used to create connected networks of open space that include traditional parks and natural areas.

Source: Smart Growth Online. "Green Development Literature Search." http://www.smartgrowth.org/bibliographies/ greenlit_search/glossary.html (accessed on December 21, 2006).

City Park

Park: A place or area set aside for recreation or preservation of a cultural or natural resource and under some form of government administration, not including national or state forests or reserves.

Source: ChartTiff. "Place Name Definitions." http://www.charttiff.com/place_names.shtml (accessed on December 21, 2006).

A Road through the Trees

If you watch television, chances are good that you have seen at least one advertisement showing a car or sport utility vehicle cruising up a forested mountain road or across a rocky plateau. As advertisers hope, those ads make many consumers see their cars as their ticket to freedom, beauty, and wilderness. But some people see the ads differently. For them, cars and roads are the very things destroying beauty and wilderness in many parts of the world.

To see how strongly people feel about roads in our wildest places, consider the wide differences in opinion about roadless areas in our national forests.[1] In 1998, the head of the Forest Service declared that he was placing a temporary moratorium on road-building in the national forests. He pointed out that our national forests already have about 400,000 miles of roads. He suggested that we should think about how to care for and manage our forests in the future, especially in areas that have never had roads at all. In 1999, the Forest Service extended the moratorium. And then later that year, then-President Bill Clinton indicated that the time had come to stop all road-building and timber-cutting in the remaining roadless wilderness areas within our national forests. Before he left office in January 2001, President Clinton set aside about one-third of all federally owned forestland as being off limits to road-building and to most logging. Soon after President George W. Bush took office, however, he put the measure on hold.

The head of the Forest Service and the former President supported the bans on road-building in national forests because it has been their position that roads are detrimental to forested lands.[2] Roads cause erosion and water pollution.[3] They fragment wildlife habitat.[4] They increase the presence of humans in wilderness areas in this country. Some people are especially upset because the government has subsidized road-building.[5] For example, it has allowed timber companies to harvest a certain number of trees from national forests for free, in exchange for the company's building the road to those trees. That, say critics, is a free ride for which the public should not be paying.

But opponents to the ban maintain that roads are necessary to reach timber. And they don't think it's bad to subsidize road-building because, they say, once a timber company builds a road, people can continue to use it for years to come, thereby increasing access for camping, hunting, fishing, and other outdoor pursuits. So the public benefits from the road in the long run. It is their position that our national forests were created for use by the people, not for preservation of habitat. Many believe it's possible to harvest timber from these areas without harming the species that live in the forests.

At the heart of this controversy are some very basic questions. Who decides what the purpose of our national forests is? And how do we resolve differences of opinion about what the future of our national forests should be and how they should be managed?

[1] Bengston, David, and David Fan. "Attitudes Toward Roads on the National Forests: An Analysis of the News Media." Draft version of December 22, 1997. http://www.treesearch.fs.fed.us/pubs/11267 (accessed on December 15, 2006).
[2] American Institute of Biological Sciences. "Washington Watch: U.S. Forest Service Proposes Ban on Road Construction." http://www.aibs.org/washington-watch/washington_watch_2000_09.html (accessed on December 15, 2006).
[3] Ibid.
[4] Ibid.
[5] *Christian Science Monitor.* "Roadless Areas Get Protection—For Now." http://www.csmonitor.com/2006/1207/p03s03-uspo.html (accessed on December 15, 2006).

Forest Quotes

1. "Because a road is one of the most indelible marks man can leave on the landscape, it is our responsibility to safeguard the often irreplaceable ecological value of unroaded areas until a permanent policy can protect our last great open spaces, our water and wildlife, and the economic health of forest communities…. We are therefore calling an official time out, so we can examine the science, involve the public, and build a roads policy for the 21st century."[6]
—Dan Glickman, former Secretary of Agriculture

2. "And last night I saw a Forest Service spokesman come on the air and say, 'They just need to understand that all we're doing is asking for a time-out for 18 months for us to get our plan together.' And I thought to myself, 'How many paychecks have you lost because you had to face being out of work?' They don't."[7]
—Helen Chenoweth, former Republican Representative from Idaho

3. A group of loggers in southern Utah has endorsed a recent U.S. Forest Service directive that halts new road-building in the roadless areas: "The bottom line is we want to maintain timber supply from here until eternity, so that my kids can grow up and take over the company…. We are fearful that down the road, there's not going to be any more timber, that the big corporations will come in and take all the lumber and head on out. We want to maintain a healthy forest and maintain a timber supply to maintain our needs."[8]
—Clark Chappell, owner of Boulder Mountain Log Homes

4. "Environmentalists complain that … roads, cut for the timber companies and maintained by the Forest Service, are degrading watersheds, filling streams with silt, and subdividing wildlife habitats. It is simply time to stop logging our national forests."[9]
—Carl Pope, Sierra Club executive director

5. "Our performance should be based on the long-term health of the land … rather than the number of board feet produced."[10]
—Mike Dombeck, former chief of the U.S. Forest Service.
(Dombeck, who has traveled more than his share of forest roads, agrees that they cause problems. But he's not a "zero cut" forester; he believes there's a place for the timber industry on federal lands. Without harvesting, he points out, forests become overgrown and can be destroyed as quickly by fires as they are by overlogging.)

6. "While we can disagree over the level of resource uses in the national forests, the American Forest & Paper Association doesn't think this administration has the right to change the multi-use purpose of the national forests without involving the public and its representatives. Unfortunately, this is what … Forest Service Chief Mike Dombeck has done with the moratorium on new roads in national forests, which virtually shuts down many

[6] USDA Forest Service. "Forest Service Limits New Road Construction in Most National Forests." Forest Service News Release no. 0054.99. http://www.fs.fed.us/eng/road_mgt/nr-11feb99.shtml (accessed on December 15, 2006).
[7] PBS Online. "Through the Woods, June 19, 1998; The NewsHours with Jim Lehrer Transcript." http://www.pbs.org/newshour/bb/fedagencies/jan-june98/road_6-19.html (accessed on December 15, 2006).
[8] Israelsen, Brent. "Say What? Loggers Say No New Roads in Roadless Areas." *Salt Lake Tribune*, April 2, 1998.
[9] Thompson, Dick. "Ruckus in the Woods; Ex-Fishing Guide Michael Dombeck Cuts a New Path for the Forest Service." *Time*, February 15, 1999.
[9] Ibid.

Forest Quotes (continued)

national forests for recreational purposes. Changing the mission of national forests is not the solution, because demand for wood and paper products will not abate. If we continue on the road to shutting down national and private forests, the demand will be filled by nations that do not adhere to our high standards. The cost to the environment and our economy will be significant."[11]
—W. Henson Moore, former president and CEO of American Forest & Paper Association

7. "Within our national forests, there are large parcels of land that don't contain roads of any kind and, in most cases, never have…. They offer unparalleled opportunities for hikers, hunters, and anglers … (and) … they're absolutely critical to the survival of many endangered species…. It is very important to point out that we are not trying to turn the national forests into museums…. This initiative should have almost no effect on timber supply. Only 5 percent of our country's timber comes from the national forests. Less than 5 percent of the national forests' timber is now being cut in roadless areas. We can easily adjust our federal timber program to replace 5 percent of 5 percent, but we can never replace what we might destroy if we don't protect these 40 million acres."[12]
—Former President Bill Clinton

8. "This [the Roadless Area Conservation Rule] was flawed and one-sided…. Boise Cascade believes that there ought to be some level of harvesting in the roadless areas because it's good for local economies and it's also good for forest health."
—Mike Moser, spokesperson for Boise Cascade timber company

9. "Ninety-nine point nine-nine percent of all roadless areas would have been protected even without this rule-making because … the agency said that it was probably only going to construct 625 miles of road, anyway, [in those areas]."[13]
—Carla Boucher, an attorney for the United Four Wheel Drive Associations, who believes the rule is not necessary

[11] Op-Ed in the Washington Post. "National Forests: Who Decides?" *Washington Post*, April 30, 1999, p. A34. Babington, Charles. "Forest Protection Plan Is Unveiled." Washington Post. October 14, 1999, p. A23.
[12] Grossman, Joe. "Blue Planet: Forest Roads Measure at Risk." United Press International, Science News, March 21, 2001. http://forests.org/archive/america/fordmeas.htm (accessed on December 19, 2006).
[13] Ibid.

Analyzing the Issue

Area of Concern and Location:

Problem:

Issue:

Parties	Interests	Beliefs	Values

Possible Solution(s):

The Components of an Environmental Issue

Understanding environmental issues can be complex. One way to investigate and analyze an issue is to look at the following components:

Problem: A condition in which something is at risk. Most environmental problems involve the interaction of humans and the environment, as well as the threat or risk associated with that involvement. (Think about what is at stake when defining an environmental problem.)

Issue: A problem, or its solution, for which differing beliefs and values exist, usually involving two or more parties who don't agree. Often, different parties disagree on how to resolve an environmental problem. This conflict turns an environmental problem into an environmental issue.

Parties: The individuals or groups who are involved in an issue.

Interests: What the concerns or interests are of each party.

Beliefs: The ideas concerning the issue, whether true or not, held by the parties. A belief is strongly tied to a person's values.

Values: The relative worth that an individual places on something. Some examples used in labeling environmental values are as follows: aesthetic, cultural, ecological, economic, educational, egocentric, legal, recreational, and social.

Solutions: The various strategies proposed to resolve the issue.

Source: Adapted from Project Learning Tree's secondary module, *Exploring Environmental Issues: Focus on Forests*, © American Forest Foundation, 1998.

Protected Area #1: Galápagos Islands, Ecuador
Seething over Sea Cucumbers

If you cruised around the Galápagos Islands, you could see Galápagos giant tortoises, weighing as much as 400 pounds. You could spy marine iguanas—the world's only sea-going lizards. And you might see flocks of finches that use tools to get their food, as well as many other unique bird species. These are just some of the many rare and unusual species that inhabit the Galápagos, an isolated chain of islands found in the Pacific Ocean about 600 miles off the mainland of Ecuador. Many of the Galápagos's species are found nowhere else on Earth. What's more, biologists estimate that the islands still have about 95 percent of their original biodiversity. For all those reasons, the Galápagos Islands—and all waters within 40 miles of their outer perimeter—were declared a protected area in 1998. The protected area is called the Galápagos Marine Reserve.

Sea Cucumber

But a recurring controversy has many conservationists concerned about the health of this protected island ecosystem. In response to pressure from local fishers, the Ecuadorian government has periodically allowed people to fish for sea cucumbers (Isostichopus fuscus) in the Galápagos. Sea cucumbers are invertebrate, slug-like animals that range in size from 2 centimeter to 2 meter. While not popular in Ecuador itself, sea cucumbers are considered a delicacy and a medicinal tonic in China and Taiwan. Thus, fishers know that they have a ready market for any sea cucumbers they catch. In fact, sea cucumbers are so popular that fishers have already exhausted the supply of them in many fishing grounds, and that's why they are so eager to fish the Galápagos.[15]

But allowing fishers into the Galápagos has been tricky. In 1995, the government opened a three-month sea cucumber season in the Galápagos, setting a total limit of 550,000 sea cucumbers. But in the first two months alone, approximately 800 fishers descended on the Galápagos, harvesting 7 million sea cucumbers![16]

Conservationists expressed their outrage—not only because of the potential damage to the food web, but also because fishers were endangering native wildlife by accidentally introducing rats to the islands and dumping their waste overboard. But the fishers were just as insistent that they had a right to those resources. They pointed out that the government allows scores of tourists onto the islands, which causes environmental damage too. But little is being done to control the tourists. The living conditions on the Galápagos, combined with high unemployment, are driving the fishers to illegally harvest the sea cucumbers. There is a lack of jobs, and there is insufficient drinking water.

[15] World Wildlife Fund. "New Study Finds Controls Inadequate to Protect Galapagos Sea Cucumbers." http://www.panda.org/about_wwf/what_we_do/marine/news/index.cfm?uNewsID=1916 (accessed on January 2, 2007).
[16] Trade and Environment Database. "Sea Cucumber Loss in the Galapagos." http://www.american.edu/ted/SEACUKE.HTM (accessed on January 2, 2007).

Protected Area #1: Galápagos Islands, Ecuador

Seething over Sea Cucumbers (continued)

In the 1995 season, the government halted the fishing season one month early. But the fishers had a quick response. The fishers entered the Charles Darwin Research Station—some armed with machetes and clubs—and took the scientists and their families hostage. The fishers threatened to destroy the giant tortoises at the center and to start fires on the islands unless the sea cucumber fishing season was restored.[17] Those incidents suggest the unresolved nature of the basic dynamics that spur conflict between conservation and development and between local residents and the national government.

Galápagos Islands

On April 29, 2005, a technical team of biologists and representatives of local fishing groups presented a report on the results of population monitoring for sea cucumbers. The results indicate that sea cucumber populations have not changed in the past 12 months but show a population that has declined substantially over the past five years.[18] The results of this and other studies help determine whether the sea cucumber fishing season will open and under what conditions.

The rulings on the fishing of sea cucumbers change from time to time. Today, the same questions remain as in 1995. Should the Galápagos Islands be open to some fishing of sea cucumbers and other species? Is it too hard to protect the Galápagos sea cucumbers when fishers have access? Can a balance be achieved between the need to protect the islands' plant and animal species and the fishers' need to make a living?

Different Perspectives on the Galápagos

1. "Continued illegal fishing is posing a threat to local sea cucumber populations and threatening to affect the unique ecosystem of the Galápagos Islands. It's vital that the government of Ecuador bring the fishery and trade under more effective control and for consumer countries and others to provide assistance where they can."[19]
   —Teresa Mulliken, co-author of a study on the sea cucumber trade and manager at TRAFFIC, the wildlife trade monitoring program of World Wildlife Fund and the World Conservation Union

2. A local fisherman commented that the ecologists say they are trying to protect the environment, so they block us [fishermen] from making a living, but for foreign tourists, anything goes.

[17] Galápagos Coalition. "Seizure of Charles Darwin Research Station by Sea Cucumber Fishermen." http://www.law.emory.edu/PI/GALAPAGOS/EnvironmentalFrameset.html (accessed on January 9, 2007).
[18] Charles Darwin Foundation for the Galapagos Islands. "Scientists and Fishermen Present Results of Sea Cucumber Population Monitoring." http://www.darwinfoundation.org/news/news29042005.html (accessed on January 8, 2007).
[19] World Wildlife Fund. "New Study Finds Controls Inadequate to Protect Galapagos Sea Cucumbers." http://www.panda.org/about_wwf/what_we_do/marine/news/index.cfm?uNewsID=1916 (accessed on January 2, 2007).

Protected Area #1: Galápagos Islands, Ecuador

Seething over Sea Cucumbers (continued)

3. "The irony is the Galápagos has the highest environmental protection of any marine habitat in the world. But it's all on paper."[20]
—Jack Grove, marine biologist

4. A former congressman for the Galápagos Islands commented that people can't just see the Galápagos as a zoo—the local people have to have help.

5. A director of the Charles Darwin Research Station commented that people who fish can still make a decent living, but their own livelihood depends on preserving the park's delicate ecosystem. They need to understand that everyone undergoes restrictions here in the Galápagos.

6. "The concerns of the protesters must be addressed—but through existing legal mechanisms established under the Special Law for the Galapagos and in ways that do not undermine either the long-term livelihoods of the fishermen or the ecological and overall economic health of the islands."[21]
—Guillermo Castilleja, World Wildlife Fund's Vice President for Latin America and the Caribbean

[20] Miller, Ken. "Ecological Crisis Looms for Fragile Galapagos." Gannett News Service, February 10, 1995.
[21] World Wildlife Fund. "Siege Shuts Down Park; Threatens Galapagos Wildlife." http://worldwildlife.org/news/displayPR.cfm?prID=76 (accessed on January 5, 2007).

Protected Area #2: Pelekunu Preserve, Hawaii
Alarmed about Invasives in the Nature Conservancy Preserves

The Hawaiian Islands are a place of incredible beauty and a place of amazing biodiversity. You'll find more than 800 flowering plants that grow nowhere else on Earth, rare birds, and two unique mammals: the Hawaiian Monk Seal and the Hawaiian Hoary Bat. The main reason Hawaii's biodiversity is unique is that the islands are located about 2,500 miles from the nearest continent. The remoteness of the islands has allowed unique species to evolve. Hawaiian plants and animals evolved in nearly complete isolation, and more than 90 percent of the native terrestrial plants and animals in Hawaii are found only in the Hawaiian islands.

Napali coastline on the Hawaiian island of Kauai

But many of the islands' species have gone extinct—and many others are at risk—from invasive species. (An invasive species is a plant, animal, or other organism that is nonnative to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or to harm human health.)

The Polynesians sailed to Hawaii more than 1,500 years ago and introduced pigs to the Islands.[22] Later, British Captain James Cook and his shipmates released European pigs, sheep, cattle, and goats.[23] Those invasive species ate so much vegetation that they reduced the habitat quality for native wildlife. Later introductions—most notably rats, mongoose, and cats—dramatically reduced the number of bird species. Hawaii was home to more than 140 types of birds; now more than half of them are extinct. Of the surviving species, approximately half are endangered.[24] As a result, conservationists are working hard to combat invasive species.

The Nature Conservancy (TNC) is working to protect the biodiversity of Hawaii on TNC's preserves. One key part of TNC's conservation efforts is protecting Hawaii's native plants and animals, as well as keeping the nonnative, invasive species out.

Pigs, which are not native to Hawaii, uproot native plant species, open up the ground so that invasive species can take hold, and create muddy wallows where disease-carrying mosquitoes can breed. Avian malaria, a mosquito-borne disease, is suspected of being a major cause of the decline of Hawaii's forest birds.[25]

[22] National Park Service, Hawaii Volcanoes National Park. "People of the Islands." http://www.nps.gov/havo/historyculture/people.htm (accessed on January 9, 2007).
[23] U.S. Geological Survey. "Hawaii and the Pacific Islands." http://biology.usgs.gov/s+t/SNT/noframe/pi179.htm (accessed on January 9, 2007).
[24] Conservation Hawaii. "Native Forest Birds of Hawaii." http://www.state.hi.us/dlnr/dofaw/consrvhi/forestbirds/ (accessed on January 9, 2007).
[25] TenBruggencate, Jan. "Nature Conservancy Ripped Over Traps." *Honolulu Advertiser*, April 17, 1996.
[26] Rosenberger, Jack. "Attack of the Feral Pigs: Non-Indigenous Species Are Crowding out the Natives." *E: The Environmental Magazine*. October 1994.

Protected Area #2: Pelekunu Preserve, Hawaii
Alarmed about Invasives in the Nature Conservancy Preserves
(continued)

To keep out the worst of the invasive species on the TNC preserves, TNC officials decided to set snares for wild goats and wild pigs. TNC decided to use the snares only after attempts to hunt the animals and to use fences to control them did not work. In 1989, TNC started setting snares, eventually setting out 1,410 in its Molokai preserves.[26]

But word got out, and soon some people began protesting TNC's actions. The first to complain were members of the organization called People for the Ethical Treatment of Animals (PETA). Two PETA representatives helicoptered to the Pelekunu Preserve on the island of Molokai, destroying 700 snares and collecting evidence about the effects of snares. They said that the snares were inhumane and that snared animals often died of starvation, infection, or dehydration.[27]

Next to complain were local hunters. According to a number of researchers, hunting is a very important subsistence activity for many Hawaiian families on Molokai. Hunting provides food for low-income families, offers a form of recreation and stress-relief, and reinforces the cultural strength of the community. Through hunting, families learn about wildlife, special places, and how to love and care for the land. The hunters were angered that TNC's snares might completely eradicate the wild pigs, goats, and deer on the wildest part of the island.

All of those complaints left TNC staffers in a difficult position. They wanted to control the invasive species to protect Hawaii's dwindling native species, but they also understood the importance of respecting the economic, social, and cultural needs of the local people.

How could those different parties find a way to balance their concerns?

Different Perspectives on the Hawaiian Island of Molokai

1. "The decision to use snares was not one we came to lightly.… A feral pig can rototill 100 square feet of rain forest in a single morning. The forest is a giant salad to them."[28]
   —Alan Holt, TNC spokesperson

2. The Nature Conservancy claims that "in exceptionally remote areas, we have no choice but to continue snaring or risk losing our watershed forests and the native plants and animals that live there."[29]

3. "The Nature Conservancy has squandered many opportunities to end the terrible animal suffering caused by (its) cruel snaring in Hawaii."[30]
   —PETA representative

4. A native Hawaiian hunter commented that the pigs have "walked with our ancestors" in ancient time and that "much of our culture" is built around this animal.

5. A Hawaiian botanist commented that the pig plays a part in the Hawaiian culture. The forests, which are being destroyed by the pigs, play a larger part in the Hawaiian culture.

[27] Ibid.
[28] Ibid.
[29] Ibid.
[30] TenBruggencate. "Nature Conservancy Ripped Over Traps."

Protected Area #3: Blockhouse Point Conservation Park, Maryland
The Techway: Bridge over Troubled Commuters

In cities and suburbs across the country, traffic is getting worse. As a result, many people are spending more time on roadways as they commute to and from work. Things have gotten so bad that the term "rush hour" is being replaced by "peak period" to more accurately describe the length of time that commuters spend in their cars.

The Washington, D.C., metropolitan area—encompassing Northern Virginia, Washington, D.C., and parts of Maryland—is one of the nation's leaders for the annual number of hours a commuter spends in traffic. In particular, commuters who travel from parts of Northern Virginia to parts of Maryland are limited in their route options and, therefore, face hours of traffic going from one suburb to the other. Businesses in Maryland and Virginia say they are losing employees who travel between Montgomery County and Northern Virginia because of the traffic conditions.

One project being explored to alleviate the congestion is the combination of a limited-access "Techway" and a bridge crossing the Potomac River north of the American Legion Bridge. The Techway would connect job and population centers in suburban Montgomery County, Maryland, and Fairfax County, Virginia, and the new bridge would provide an alternative crossing point between those two counties. Proponents of the Techway contend that the new route would reduce a peak-period commute from two hours to 20 minutes, and would help alleviate road rage and air pollution. However, opponents of the plan argue that there is a potential for negative environmental consequences. And, they say, new roads could disturb established neighborhoods in the area of Potomac, Maryland.

Opposition to the plan comes from groups such as the Montgomery County Council and the Maryland National Capital Park and Planning Commission. They believe that the likely routes could cross three parks, 17 streams, and the C & O Canal, thereby negatively affecting both water quality and open space.

One of the proposed crossing points is the Blockhouse Point Conservation Park, an area that is off limits to horses and bicycles because it is home to a number of rare plant species. Blockhouse Point also contains one of the area's largest tracts of undeveloped forest suitable for forest interior–dwelling bird species, such as the bald eagle. A citizen's action group, Solutions Not Sprawl, believes that a new bridge across the Potomac River and its connecting super-highways will not solve the traffic problems. The group also believes that the cost of this project would far outweigh the benefits and that it would be harmful to the environment, parkland, and established neighborhoods that it would cut through.[31]

Conversely, groups such as the Northern Virginia Technology Council, Technology Council of Maryland, Greater Washington Board of Trade, and Marylanders for a Second Crossing support the plan for a Techway and a new bridge crossing. The Techway-bridge plan is viewed as one piece of the solution to commuter traffic that has resulted in lost work

[31] Solutions Not Sprawl. "The Techway: A Threat to Our Rural Wedge and to the Heart of the Ag Reserve." http://www.solutionsnotsprawl.org/techway2.htm (accessed on January 10, 2007).

Protected Area #3: Blockhouse Point Conservation Park, Maryland
The Techway: Bridge over Troubled Commuters (continued)

hours, lower productivity, increased stress and frustration, and lost family and personal time.[32]

Should the Techway and a new Potomac River bridge be built? Can it be done without disrupting neighborhoods, and affecting water quality and protected park areas? Can the increasing traffic problems be alleviated without an additional bridge and Techway?

Different Perspectives on the Techway

1. "The quality of life of people is the endangered species. I view land as a resource for the use of people."[33]
   —John T. "Til" Hazel Jr., developer

2. "If you build a new road, all you do is encourage more extreme commuting and in the process throw 35 years of land-use planning out the window. I'm totally opposed to that."[34]
   —Nancy Dacek, Member, Montgomery County Council

3. "Initially I was for the bridge crossing. I mean, anything to relieve the traffic. Something has to be done.… I'm very concerned that a quick decision will be made to throw a bridge over the Potomac as a Band-Aid® for a process that needs some in-depth analysis.… There is a problem, but there are also many, many possible solutions. Why not examine all of them?"[35]
   —Peter Kreeger, resident of Potomac, Maryland

4. "A second crossing will only cause a shift in traffic to adversely affect an environmentally sensitive area and promote increased commercial development and sprawl."[36]
   —E. Clayton Embrey Jr., resident of Potomac, Maryland

5. "I am frustrated as many are with the growing traffic congestion in the Washington Metropolitan Area. I have and will continue to strive to get Maryland and Virginia working as a region to solve these massive traffic problems. I believe we must build an integrated transportation system of roads and cost-effective useable mass transit that links our region and does not stifle the economic growth that is the engine driving the economy of our state and country.… Therefore, I do support a new Potomac Crossing and will support that in every manner possible.[37]
   —Senator Patrick J. Hogan, Maryland State Senate (D)

[32] Sunnucks, Mike. "Road Rage: Techway Backers Cry Foul Over 'Scare' Tactics." Washington Business Journal. April 6, 2001. http://www.solutionsnotsprawl.org/archives/biz040601a.htm (accessed on January 10, 2007).
[33] Fisher, Marc. "Studying the Gap Between Birds and Builders." Washington Post, April 5, 2001.
[34] Phillips, Angus. "At Planning Crossroads, a Highway to Ruin." Washington Post, April 8, 2001.
[35] Wraga, Monica P. "Residents Advocate Solutions, Not Bridge." The Gazette, April 4, 2001.
[36] Embrey, E. Clayton Jr. "Go Montgomery—Ruin Montgomery." Public Opinion article in Connection Newspapers, July 17, 2002. http://www.connectionnewspapers.com/article.asp?archive=true&article=7430&paper=70&cat=132 (accessed on January 10, 2007).
[37] Marylanders for a Second Crossing Inc. "Comments From Elected Officials." http://secondcrossing.org/ (accessed on January 10, 2007).

Protected Area #4: Katmai National Park, Alaska
Gridlock with the Grizzlies

Every year, bears gather at the Brooks River in Katmai National Park, Alaska, to feed on red salmon. As the fish move upstream to their spawning grounds, the bears prowl the waters to snag fat-rich fish snacks. Dozens of bears may gather along the short river during the red salmon run. Although the bears are normally solitary animals, they tolerate each other's close company along the river because of the tremendous abundance of fish. And one of their favored fishing spots is the Brooks River Falls where the fish leap out of the water as they try to jump the six-foot falls.

The annual arrival of red salmon attracts more than bears to the Brooks River. Each year, hundreds of fishers travel to the river to try their hand at catching salmon. But the number of fish is small compared to the thousands of tourists from all over the world who travel here to watch the bears. Some of the visitors fly or boat into the campground or stay at the lodge located at the mouth of the Brooks River. But many people also come, watch bears for a few hours, and then leave again all in the same day. Although the campground and lodge can accommodate about 120 people combined, more than four times that number may arrive just for the day. And since 1986, the annual number of people visiting Katmai has doubled.

All those people combined with all those bears in such a small area makes Park Service rangers nervous. The bears are, after all, big and potentially dangerous animals. And although there has never been a bear attack at Brooks River, many rangers worry that the situation is just an accident waiting to happen. Having so many people around may also negatively affect the bears' ability to survive. To reduce the chance of bear-human encounters, the Park Service has built several viewing platforms along the river to give people a safe place from which to watch the bears. Rangers also monitor human and bear movements as best they can, encourage people to give bears the right of way, and stand ready with rifles to protect people, if necessary. But there are a lot of visitors and only a few rangers.

Worried about the health and safety of bears and visitors, along with wanting to ensure a continued positive experience for the people who trek out to the Brooks River (a roundtrip floatplane ride costs hundreds of dollars), the Park Service has developed a plan to better manage this area of the park. They would like to move the campground, lodge, and other facilities, currently located on the north side of the river, to the other side of the river and to take out the bridge that spans the river. This change would give the bears free access to the whole area on the north side of the river and would remove visitor facilities from known archaeological sites. It would also mean that people and bears would no longer be involved in traffic jams on the bridge. (Currently, if a bear gets close to or crosses the bridge, Park rangers keep people from using the bridge until the bear is a safe distance away. Sometimes people can wait for half an hour or more for the bridge to clear.) The Park Service wants to escort all visitors to designated bear viewing spots, instead of letting people wander at will. And they want to limit the number of day visitors to 85 people per day.

Some people applaud the Park Service's plan to resolve the people and bear conflicts at the Brooks River. Others condemn it, saying it is not necessary, will cost too much money, and will ruin the experience. The opponents

Protected Area #4: Katmai National Park, Alaska
Gridlock with the Grizzlies (continued)

contend that the Park Service should not be limiting the number of people in the area but instead should be developing ways to manage more visitors. What do you think?

Different Perspectives on Katmai

1. "People who travel to Brooks for the day tend to be less accustomed to the outdoors and are harder to manage. Limiting the number of day visitors will help preserve the uncrowded, wilderness-like quality of the visitor experience."[38]
   —Katmai National Park ranger

2. "Tourists want to see bears, and the Park Service should cater to that desire. [The Park Service] should build more boardwalks and viewing areas to increase the number of visitors it can handle at Brooks. [It] shouldn't move Brooks Camp. Anyone who wants to have a wilderness experience can do so in the other 4 million acres of the park."[39]
   —David McGuire, Anchorage orthopedic surgeon, owner of Quinaat Landing Hotel in King Salmon and operator of a daily boat service to Brooks

3. "Brooks Camp should be moved off the archaeological sites and away from the bears' favored beach. But limiting day users makes them second class citizens. Tourists in Alaska like to do a variety of things, and popping in to see bears for an afternoon is perfect. We'd like to expand—not limit—the number of visitors who visit here each year."[40]
   —Tom Hawkins, operations chief for Bristol Bay Native Corporation

4. "The Brooks River is one of the most beautiful spots we have. It's accessible, and you can see the bears in a natural area. In recent years, the Bristol Bay economy has been hurt by poor salmon runs. Limiting visitor access to Brooks will further hurt businesses in this area."[41]
   —Senator Ted Stevens (R-AK) and chairman of the Senate Appropriations Committee

5. "This is wilder than I thought it would be. I was kind of hoping we would have a ranger along."[42]
   —Kirsten Schultze, day use visitor

6. "For the price we paid to come out here for a day, we should be able to come and go when we like."[43]
   —Barb Collins, day use visitor

7. "This park should be managed for the protection and well-being of the bears first and for visitor access second. If this isn't done, inevitably, there's going to be human and bear conflict—and then everyone will lose. I'm willing to sacrifice some of my freedom of movement here in order to help give the bears the right of way."[44]
   —Dan Bogan, Brooks camper

[38] Rinehart, Steve. "Traffic Jams at Brooks River." *Anchorage Daily News*, July 26, 1998. A1.
[39] Ibid.
[40] Ibid.
[41] Ibid.
[42] Ibid.
[43] Ibid.
[44] Personal interview with Dan Bogan.

Protected Area #5: Florida Everglades, Florida
At War with Water

The Florida Everglades is an ecosystem with severe problems. It was once a vast, free-flowing "river of grass" that stretched across more than 730 square miles of southern Florida. Each year, the Everglades would flood for about six months after the spring rains. Following that, the Everglades would experience a six-month drought. Although the plants and animals of the Everglades were adapted to this wet–dry cycle, it wasn't very conducive to farming or human settlement. In fact, many people in the late 19th century viewed the Everglades as nothing more than a mosquito-infested wasteland.

In the 1950s, approximately 500,000 people lived in the Everglades. They had suffered through floods, hurricanes, droughts, and fires. To help those people, Congress authorized the Central and Southern Florida Project.[45] This water management project was built to provide flood protection and to provide water for people and agriculture. Huge channels and pumping stations were built to drain water away from farms and cities during the wet season, and then to pump the water back during the dry season.

Today's population of approximately six million people is three times greater than what the project was designed to serve. In addition, the project has had many harmful effects on the environment that were not predicted. For example, wading birds nesting in the Everglades have declined 90 percent, and 68 plant and animal species are listed as threatened or endangered.[46] This change is due in large part to the excessive drainage of the wetlands and changes to the natural flow of water.

The water quality in the Everglades is also declining. Pollutants from urban and agricultural runoff, including phosphorous, metals, and pesticides, have harmed the plants and animals in the region.

With an ever-growing human population in south Florida (about 900 people move to Florida daily), people are realizing that too much water is being pumped out of the Everglades. Soon there may not be adequate water supplies for south Florida's growing human communities.

To restore the Everglades so that it resembles its natural state, political figures at the state and federal level have been working on a Comprehensive Everglades Restoration Plan. The plan is designed to capture freshwater headed for the sea and to direct it back to the ecosystem to revitalize it. One estimate is that the plan will cost approximately $7.8 billion and will take more than 20 years to complete.[47] Not surprisingly, such a plan will affect almost everyone in south Florida.

The growing demand for water for the expanding human population, as well as for agriculture and industry, has caused many conflicts and heated debates. Conservationists hope to restore significant portions of the original Everglades wetlands to protect alligators, panthers, and wading birds and to improve overall water quality. Local sugar farmers are agreeable

[45] Comprehensive Everglades Restoration Plan. "Why Restore the Everglades—Part 4: Ecosystem Problems Center on Water." http://www.evergladesplan.org/about/why_restore_pt_04.aspx (accessed on January 18, 2007).
[46] Ibid.

Protected Area #5: Florida Everglades, Florida
At War with Water (continued)

to some limits on their phosphorous runoff, but they are opposed to changes in water quality regulations. Local Miccosukee Indians want the Everglades restored, but they are opposed to the flooding out of some nearby residents. The local residents are divided in their beliefs. Some are wary of environmental protection, but they are concerned about drinking water supplies and safety. Others are fully committed to protecting the wild habitat of their region.

Different perspectives on the Everglades

1. The Everglades Coalition is an alliance of 45 local, state, and national conservation and environmental organizations that are dedicated to full restoration of the greater Everglades ecosystem. They advocate for the restoration and protection of the greater Everglades ecosystem.

2. "But I would say that even if you don't care about the panthers and the gators and the otters and the royal palms and the wild orchids and all the other magical things in there, if you live in South Florida, what's bad for the Everglades is probably bad for you."[48] *—Michael Grunwald, an investigative reporter who has written a book on the Everglades titled The Swamp: The Everglades, Florida, and the Politics of Paradise*

3. "The historic Everglades are a vast wetland of international significance. [The area constitutes] a single, biotic engine that drives the cycles and systems that support all life in south Florida. As such, this unique ecosystem has been the focus of the largest hydrologic restoration program ever attempted."[49] *—From the Everglades National Park homepage*

4. Jesse Hardy, a holdout homesteader, is fighting for his right to stay on his land in the middle of an Everglades restoration project. An attorney for Hardy filed a 43-page lawsuit against state and federal agencies planning the restoration of Southern Golden Gate Estates. Hardy is 68 years old and is a disabled Navy veteran. He has refused numerous land swaps and an offer of more than $4 million.[50]

[47] Ibid.
[48] Naples Daily News. "The Story of the Everglades." May 21, 2006. http://www.naplesnews.com/news/2006/may/21/story_everglades/ (accessed on January 18, 2007).
[49] Everglades National Park. "Saving the Everglades." http://www.nps.gov/ever/ (accessed on January 18, 2007).
[50] Staats, Eric. "Holdout Landowner's Attorney Sues State, Feds." Naples Daily News. November 6, 2004. http://www.naplesnews.com/news/2004/nov/06/ndn_holdout_landowner_s_attorney_sues_state_feds/ (accessed on January 18, 2007).
[51] Cox, Jeremy. "New Timeline, Priorities for Everglades Restoration." Naples Daily News. January 14, 2007. http://www.naplesnews.com/news/2007/jan/14/new_timeline_priorities_everglades_restoration/?local_news (accessed on January 18, 2007).

Protected Area #5: Florida Everglades, Florida
At War with Water (continued)

5. Joette Lorion, a Miccosukee spokesperson, accused the U.S. Army Corps of Engineers of "just pushing paper." She warned that unless contractors begin removing blockages soon in the flow of water into Everglades National Park, the ecosystem will die.[51]

6. Judy Sanchez, spokeswoman for U.S. Sugar Corporation in Clewiston, said sugar is a scapegoat for the ecosystem's problems because people do not know enough about the sugar industry. Sanchez said, "We're an easy target. We're out here relatively isolated from everyone. We're in a highly visible business because we're so different and it's something they don't know much about."[52]

7. "My feeling is we just need somebody to take charge. Right now, we're just trying to please everybody and nothing is getting done.... It's just a big mess."[53]
—*Terry Rice*

[52] Spinner, Kate. "We're an Easy Target." Naples Daily News. March 5, 2006. http://www.naplesnews.com/news/2006/mar/05/were_easy_target/ (accessed on January 18, 2007).
[53] Cox. "New Timeline, Priorities for Everglades Restoration."

3 Potatoes, Pesticides, and Biodiversity

Students will develop an understanding of some of the costs and benefits of using ***pesticides*** and of how those products affect biodiversity. They will research pesticides and learn about alternatives to the reliance on pesticides for growing potatoes.

Level
Grades 9-12

Subjects
Biology, Chemistry, Environmental Studies

Concepts
1.6; 2.2; 3.3; 4.3; 4.5; 5.5.
See the Conceptual Framework for a complete description of the concepts.

Skills
Analyzing, Defining Issues, Discussing, Organizing Information, Researching, Presenting

Materials
Bags of potato chips; two almost-identical potatoes; copies of the student pages. Optional: Copies of the "Pesticide Resources for Educators and Students."

Time Considerations
Part A: One-Two 50-minute periods, plus homework
Part B: One 50-minute period
Part C: One-Two 50-minute periods

Related Activities in Other PLT Guides
PreK-8 Guide: Planet Diversity; Charting Diversity; Viewpoints on the Line; Pollution Search; Web of Life; Life on the Edge.

Focus on Risk module: Things Aren't Always What They Seem; and Special Topic – Chlorine: Looking at Tradeoffs.

Places We Live module: Regional Community Issues: The Ogallala Aquifer.

Objectives
- Students will learn what pesticides are and what they are used for.
- Students will describe some of the costs and benefits of using pesticides.
- Students will examine some of the decisions that potato farmers must make and the challenges they face.

Assessment Opportunities
- Use students' class discussions and completed "Insecticide Information Sheet," "Herbicide Information Sheet," and "Fungicide Information Sheet" to assess their understanding of the effects of pesticides.
- Use students' class discussions and completed "Fields of Change Question Sheet" to assess their understanding of the challenges and successes that farmers may have when reducing pesticide use.
- Have students cut out an article from a recent newspaper or magazine (or find one on the Internet) about pesticide effects on wildlife and biodiversity. Then have them write down a few thoughts about their article on an index card. Have students bring both to class for a "Current Events" bulletin board and discussion.

Background

Walk through a garden supply shop, the household supply section of your local supermarket, or the insect repellent section of your local sporting goods store, and you will find a wide assortment of products designed to help you fight off everything from mosquitoes to mold. This plethora of ***pesticides*** is a testament to the explosive growth of synthetic chemicals since World War II. The chemical era has helped bring us an abundant and inexpensive food supply, labor-saving means to rid our homes and gardens of pests, and effective tools to combat disease-causing organisms. But many of those chemical wonders have also turned out to have unwanted—and often serious—ecological consequences. Some pest species are increasingly immune to the effects of pesticides, forcing companies to develop ever more-potent compounds.

Toxic chemicals, which include pesticides, have been identified as one of the major threats to the Earth's biodiversity. Across the globe, pesticides affect not only the organisms they were designed to kill, but also a broad spectrum of other living things. Pesticides can poison beneficial organisms such as earthworms, predatory insects, and soil microorganisms; pollute water supplies; and threaten human health.

What Is a Pesticide?

According to the U.S. Environmental Protection Agency (EPA), a pesticide is "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest." Pests are living organisms that occur where they are not wanted or that cause harm to crops, humans, or animals. Examples of pests include insects, mice and other animals, unwanted plants (weeds), fungi, and microorganisms such as bacteria and viruses. Although "pesticide" is a generic term for all the substances designed to kill such pests, more specific terms will refer to particular types of pesticides. For example, ***insecticides*** are pesticides that kill insects and other arthropods; ***fungicides*** kill fungi, including blights, mildews, molds, and rusts; ***herbicides*** kill weeds and other plants that grow where they are not wanted; and ***biocides*** kill microorganisms.[2]

Types of Pesticides

Pesticides may be classified in different ways, such as by the organisms they are designed to kill (see previous paragraph), by their chemical structure, by the ways in which they work, or by who can use them. For example, "general use" pest control products may be used by anyone; "restricted use" pesticides may be applied only by certified applicators or people being supervised by the certified applicators.[3]

Pesticides differ in their toxicity. The toxicity of a substance refers to its ability to cause injury to a living system. In other words, if you know how toxic a pesticide is, then you know how poisonous it is.[4] Some pesticides are very poisonous, or toxic, and may seriously injure or even kill humans. Other pesticides are relatively nontoxic.

In addition, pesticides can cause either acute or chronic toxicity. Acute toxicity is used to describe effects that appear soon after being exposed to a pesticide—for example, effects that occur within 24 hours of exposure to a pesticide. Chronic toxicity results after repeated exposure to a pesticide over longer periods of time.

For many pesticides, the toxic effects of a single acute exposure may be quite different from the effects caused by chronic exposure. For example, if large amounts of the pesticide cryolite are eaten by rats at one time, little or no harmful effects will be observed because it quickly passes through the intestinal tract and is eliminated without harmful effects. However, if rats eat small amounts of cryolite every day, the pesticide can be absorbed and cause chronic illness and death.[5]

Pesticides differ in the length of time they persist in the environment after they have been applied. Many pesticides begin to break down soon after being applied, but just how long it takes a pesticide to break down varies from one pesticide to another and can depend on where the pesticide is applied. For example, some pesticides break down in water in a matter of hours, but they may take longer when sitting on plants or soil. And some pesticides are persistent—they do not break down in the environment for a long, long time. Just what a pesticide will break down into will also vary. Some pesticides break down into benign compounds; others have breakdown products that are toxic to living things—and some of those toxic breakdown products are persistent.

Pesticides entering our waterways can be toxic to waterfowl and fish species.

One of the most troublesome group of pesticides are those that are classified as persistent organic pollutants, or POPs. POPs are a set of chemicals that are toxic, that persist in the environment for long periods of time, and that biomagnify as they move up through the food chain.[6] When a substance biomagnifies, it works its way up the food chain by accumulating in the fat of living organisms and by becoming more concentrated as it moves from one creature to another.

Chlordane, DDT, aldrin, and several other pesticides are all POPs. POPs have been linked to adverse effects on human health and animals, such as cancer, damage to the nervous system, reproductive disorders, and disruption of the immune system. Because they circulate globally through the atmosphere, oceans, and other pathways, POPs released in one part of the world can travel to regions far from their source of origin.

On May 23, 2001, the United States signed the Convention on Persistent Organic Pollutants at a diplomatic conference in Stockholm, Sweden. Under the Convention, countries committed to reduce or eliminate the production, use, or release of the 12 POPs of greatest concern to the global community and to establish a mechanism by which additional chemicals may be added to the treaty in the future. The United States strongly supported efforts to complete this important agreement, which has wide-ranging environmental and health benefits.[7]

Although the manufacture and the use of pesticide POPs have been banned in this country, residues from those chemicals can still be found in sediments at the bottoms of waterways. POPs can be deposited in marine and freshwater ecosystems through effluent releases, atmospheric deposition, runoff, and other means. Because POPs have low water solubility, they bond strongly to particulate matter in aquatic sediments. As a result, sediments can serve as reservoirs or "sinks" for POPs. When sequestered in those sediments, POPs can be taken out of circulation for long periods of time. If disturbed, however, they can be reintroduced into the ecosystem and food chain, potentially becoming a source of local—and even global—contamination.[8]

DDT is a pesticide POP that can stay in the environment long after it is applied—up to 12 years. The production, import, or export of DDT has been banned in the United States; however, it is still being used in some parts of the world to control malaria. As cost-effective alternatives to controlling malaria become available, the use of DDT will be phased out.

The Label Is the Law

If you have ever purchased a pesticide for use in your home or garden, you have probably seen the detailed labels that manufacturers provide to make consumers aware of health concerns and precautions for use. All pesticides sold or distributed in United States—from large containers of agricultural pesticides to single cans of bug spray—have to be registered with the EPA and must carry a label. The label must provide information regarding the use, storage, and disposal of the pesticide. The label must also include words that caution the reader as to the toxicity of the product. For example, words such as "Danger—Poison," "Warning," and "Caution" are found on pesticide labels.

What's in a Name?

Any given pesticide has several different names. Pesticides have a common name, a chemical name that describes their structure, and one or more common product names—the names that people see most prominently at the store. For example, the herbicide glyphosate (common name) has the chemical name N-(phosphonomethyl)glycine and is sold under the product names such as Roundup® and Rodeo®.

Threats to Biodiversity

In her 1962 book titled *Silent Spring*, Rachel Carson documented the devastating effects of pesticides on wildlife and raised warnings about threats to human health. In the United States, the production and use of many of the pesticides she wrote about, such as DDT, have been phased out. Today, however, more than 500 species of insects and mites and approximately 150 types of fungi are resistant to some pesticides. That resistance to pesticides has resulted in increasing pesticide applications; combining pesticides; or substituting more expensive, toxic, or ecologically hazardous pesticides to combat pests.[9] In the United States, we now use about 4.6 *billion* pounds of pesticides each year—chemicals that move through the soil, through the water cycle, and through the food chains.[10]

If pesticides were toxic only to the organisms they are intended to kill, they would not pose such a huge threat to biodiversity. But some pesticides are toxic to almost everything—including birds, fish, mammals, and insects and other arthropods. Other pesticides are relatively safe for most types of living things but are extremely toxic to certain fish and other aquatic animals.[11] And many active ingredients that are used in pesticides are harmful to aquatic organisms and fish, even in the low parts-per-billion range.

Many of the nontarget species that we kill with pesticides each year are organisms that perform "services" that we benefit from directly. Nontarget organisms are organisms that the pesticides were not designed to kill. For example, pesticides may

kill beneficial, ***native*** earthworms that help break down organic matter and aerate the soil in which we grow our crops. They may also kill spiders, praying mantises, and other arthropods that help keep insect pest populations in check. And they may kill bees, upon which many of our food crops depend for pollination. Loss of such beneficial organisms may have severe economic repercussions. For example, one study estimated that the pollination losses to food production from pesticide effects on honeybees and wild bees are $200 million per year.[12] The U.S. Fish and Wildlife Service estimates that approximately 67 million birds in the United States die each year from pesticide poisoning.[13]

Pesticides and the Farmer

From seed planting until the final harvest, farmers engage in a very risky business. After all, just to get the seeds into the ground requires a significant investment of money for every acre farmed. And farmers have no control over key factors that can directly influence their yields: the temperature, the amount or timing of rainfall, the amount of wind, and when and whether the pest populations will reach destructive levels. Those key factors vary—from year to year, county to county, farm to farm, and even field to field. In addition, trying to grow crops either for direct consumer consumption or for use by food processors to manufacture packaged foods requires farmers to grow specific types of foods

using particular production practices. That requirement is because food processors typically need crops of a consistent size and type and because consumers are usually fairly particular about their produce—almost everyone wants "perfect" fruits and vegetables.

With so many unknowns and with pressures to produce particular crops, using pesticides becomes something like an insurance policy for a farmer. After all, if temperature and humidity are right, pest populations can get out of control. Applying pesticides ahead of time is a relatively inexpensive way to head off the risk of pest outbreaks. However, this reliance on synthetic chemicals results in a lot of pesticides being released into the environment. In 1994, 789 million pounds of pesticides (active ingredient basis) were used for agriculture in the United States.[14]

Although fungi, insects, and other pests have always been—and will likely always be—threats to farmers' crops, how farmers deal with those threats varies considerably. At one end of the farm management continuum are farmers who are extremely reliant on chemically intensive methods of farming. At the other end of the spectrum are farmers who use no synthetic pesticides or who are known as organic farmers. In between, farmers use a variety of management tactics, including changing the ways they plant, irrigate, and harvest their crops to reduce the chances of pest outbreaks; using less-toxic pesticides; and creating optimal conditions for beneficial organisms to help combat pests.

Farming is a risky business—and taking steps to move away from reliance on chemical-intensive methods can increase the risks involved in farming. But some farmers have been willing to take those risks because of their concerns about the problems associated with high-pesticide-use farming. This activity examines some of the constraints on farmers, and it profiles one family farm that is part of a statewide effort to reduce pesticide use in Wisconsin.

Getting Ready

Part A

Gather various bags of potato chips. Copy the Insecticide, Herbicide, and Fungicide Information Sheets and the Pota-pourri pages for each student. You also may want to make copies of the Information Sheets with the answers and the "Pesticide Resources for Educators and Students", found at the end of the activity, for each student.

Part B

Copy the "Ranking Pesticides Question Sheet" for each student.

Part C

Obtain two large, similar potatoes. Copy the "Fields of Change" article and "Fields of Change Question Sheet" for each student. Optional: Copy the "Answers to Fields of Change Questions" for each student.

Doing the Activity

Part A: Potato Chips, French Fries, and Pesticides

1. Bring in bags of several different varieties of potato chips, and pass them out to the students to eat. While the students are munching the snacks, discuss these questions with them:

- What criteria are important to them when they choose which potato chips to buy?

Answer: Flavor, texture, appearance, size, cost, and so forth.

- When they buy a bag of some particular brand of potato chips, do they expect the chips to be the same as in other bags of the same brand and flavor of chips? What if they buy the chips at two different stores in their town or city? What if they buy the chips in two different states?

Answer: Students should realize that the same potato chips manufactured and sold by a particular company are consistently the same.

- Is it important to them that particular types of potato chips are always the same? Why or why not?
- What about french fries? If they go into a fast-food restaurant, such as McDonald's or Burger King, in one part of their town or city on one day, will the french fries be the same as or different from those on another day or at another fastfood restaurant from the same chain in another part of town or another part of the country?

Answer: Again, students should realize that national chains consistently provide the same french fries at every restaurant.

- Is it important to them that a particular restaurant's french fries are always the same? Why or why not?
- How are potato chip manufacturers and fast-food restaurants able to provide such a consistent product?

Answer: They use the same kind, size, and shape of potatoes, and they have a year-round supply of those potatoes.

Now ask the students to imagine for a minute that they are farmers who grow potatoes used for chips and french fries.

- What type of potatoes would you grow?

Answer: The kind wanted by potato chip or french fry manufacturers or both.

- Would you care about the size of the potatoes you grow or the total number you grow?

Answer: Absolutely! The more potatoes you grow on every acre, the more money you'll make. Also, if your potatoes aren't the right size and shape, you may not be able to sell them or may not get a very good price for them.

- What kind of factors that might affect your crop would you have to deal with?

Answer: Weather, pest infestations, soil quality, rainfall, and other factors.

- What would happen if any one or a combination of those factors destroyed your crop?

Answer: Be sure students understand that farmers are running businesses. If their fields don't produce a crop, farmers will lose money—and one or more bad years may even bankrupt the business.

- What kinds of actions might farmers take to moderate the effects of the factors that could destroy their crops?

Answer: Most have little control over the weather. To control pests, including insects, weeds, and fungi, farmers may spray pesticides or use integrated pest management techniques. If the soil is poor in nutrients, farmers may fertilize it with an organic or synthetic fertilizer.

Tell the students that they are going to find out more about what goes into growing potatoes for chips and fries.

2. Explain that potato farmers face a variety of different pests—including insects that eat the leaves and fungi that attack the plants. Also explain that many potato farmers use a variety of pesticides to combat such pests.

- Ask your students what pesticides are.

Answer: "Pesticide" is a generic term for chemicals used to kill pests.

- Why do people use pesticides?

Answer: To kill organisms that directly (especially mosquitoes and gnats) or indirectly (eating crops and attacking trees) negatively affect people.

- Can they give examples of pesticides?

Answer: Students may know some of the brand names of some pesticides and may be familiar with common household pesticides, such as Round-Up®, Raid®, Off®, Tilex®, and Lysol®. They may also be familiar with the terms for particular kinds of pesticides: herbicides, insecticides, fungicides, and rodenticides.

3. Divide the class into three teams: a fungicide team, an insecticide team, and an herbicide team. All of those pesticides are commonly used by potato farmers. Then pass out a copy of the appropriate student pages ("Insecticide Information Sheet," "Herbicide Information Sheet," "Fungicide Information Sheet") to each team member. Explain that each team needs to fill in the chart by finding out the following information about each of the five pesticides listed on its chart.

- What are its toxicological effects? (What toxicity class is it? How toxic is it orally? Through inhalation? Is it suspected to cause cancer or any other health problems in people?)
- What are its ecological effects? (How toxic is it to birds? Aquatic organisms? Other animals?)
- What is its fate in the environment? (How long does it persist in the soil? In water? In plants?)

4. Discuss the various ways that students may divide up the work in order to complete their sheets. As the students begin working, you can refer to the student pages with the answers provided to help guide them in the kind of information they are trying to find. You can also provide students with the "Pesticide Resources for Educators and Students" information, found at the end of the activity.

5. Allow time for the three student teams to share what they found out about the pesticides that they researched.

6. After the teams share their findings, go through the student pages with the answers provided to see if anything was missed. You may choose to review this information orally only or also hand out copies to the students. Ask students if they were they surprised by any of the information they found out. Do they have any concerns about the pesticides being used by potato farmers? (Be sure that students understand that all of the pesticides they researched, as well as all other pesticides being used in the United States, are packaged in containers that contain directions for proper use. In addition, the EPA requires that people who use certain pesticides must be trained in proper application.) Use the background information provided with this activity to discuss pesticides further.

You can also use the "Pota-pourri" sheet to quiz the students about their knowledge of pesticides and potatoes if you turn the statements into questions. For example, you could ask students how many pounds of potatoes they think the average American eats or how many pounds of pesticide they think are used for agriculture per year in the United States. Afterward, pass out copies of "Pota-pourri" so the students can read through all the facts for themselves.

At the end of Part A, students should understand many of the costs and benefits of using pesticides, including why farmers use pesticides, what effects pesticides can have on nontarget species, and how heavily we rely on pesticides.

Part B: Ranking Pesticides

1. Explain to students that some people have been working to develop ways to quantify the effect that an individual farmer's farming methods are having on the environment and that the students are now going to compare the pesticides they researched. Pass out copies of the "Ranking Pesticides Question Sheet" to each student. Have students work in their teams to discuss and answer the questions on the sheet, using the information they gathered about pesticides in Part A. (Note: There are no "right answers" to this exercise. Rather, what is important is that students grapple with the issues associated with trying to rank the relative effects of different pesticides.)

2. Go over the answers that the students came up with as a group. Was it easy or difficult to rank the pesticides using only toxicological effects, ecological effects, or fate in the environment? Why? What were some issues that made it difficult to determine the "worst" and the "best" pesticide on their list? How did they arrive at their decisions?

Comparing and ranking pesticides is a very difficult job, and students may come up with a range of ways to do it. Students may note the difficulties in synthesizing what toxicity levels are for different kinds of organisms, what the ecological effects are, and what happens to each pesticide in the environment so they can use one comparative value. For example, one pesticide may be extremely toxic but may break down in the environment relatively quickly, while another is not as toxic but persists in the environment for a long time. Deciding which one is "better" to use can be difficult. Accounting for how much is needed further complicates the issue. For example, some students may point out that even though one pesticide is more toxic than another, farmers may need to apply the first in much smaller doses than the second.

3. Discuss the "Wisconsin Healthy Grown Potatoes" initiative with your students: In Wisconsin, potato growers have been working for years to reduce pesticide use. A program called "Wisconsin Healthy Grown Potatoes" has been developed through a collaborative effort by the Wisconsin Potato and Vegetable Growers Association, World Wildlife Fund, University of Wisconsin, and other conservation groups. The concept of "Healthy Grown" potatoes was conceived in the mid-1990s by a group of Wisconsin potato farmers as an experiment in large-scale, reduced-pesticide agriculture. You and your students can view a short 10-minute movie about Healthy Grown potatoes by going to the homepage of Wisconsin Healthy Grown Potatoes or by going directly to the following link: http://www.healthygrown.com/flv_player.cfm

Wisconsin Healthy Grown Potatoes has developed methods for indexing and evaluating pesticide mammalian toxicity, as well as ecological and wildlife effects. New research from diverse sciences, including biology, entomology, plant pathology, and zoology, were combined. And full-scale agricultural tests were implemented.[15]

For sustainably grown potatoes, the collaborative group developed standards that incorporate a ranking scheme for potato pesticide use. Any potatoes grown in accord with the standards developed by the group would earn an "eco potato" label.

First, the group developed a way to calculate "toxicity units" so that they could compare different pesticides. Then they developed a "toxicity factor value" (TFV) formula for each pesticide:

TFV = (0.5 x acute mammalian toxicity) + chronic mammalian toxicity + ecotoxicity + (1.5 x BioIPM impacts)

This formula gives greater weight to certain effects than to others (for example, more weight to chronic than to acute mammalian toxicity). Next, to get the toxicity units for a particular pesticide per acre for a season, the group developed another formula:

Toxicity Units = (number of pounds of active ingredient applied per acre) x (TFV for that pesticide)

(Note: It is not important that the students remember the exact formulas developed in Wisconsin. Rather, students should appreciate how this group of people came up with a way to quantify pesticide use in a comparable way. The students may also have opinions about how this system compares to the systems that they came up with to rank the pesticides.)

Second, the Wisconsin group devised a maximum number of toxicity units that could be applied to a given field during a year (a cap of 800 toxicity units per acre for short-season potatoes; 1,200 for long-season potatoes). And the group decided that a small number of pesticides should never be used on "eco potatoes" because of their tremendously harmful effects on beneficial organisms, groundwater contamination problems, or other issues. Under this system, farmers could choose the mix of pesticides that they applied over the course of the season. As long as they stayed within the toxicity unit caps, their potatoes earned an "eco potato" label.[16]

Third, the group surveyed farmers in 1998 so that each farmer would know his or her own "starting" toxicity score (the toxicity units they were applying per acre) and could see how his or her farm compared with farms of other farmers in the area. At that time, the average toxicity score was 2,153. Curiously, merely knowing where they stood in relation to other farmers spurred some farmers to reduce their toxicity units. By 2000, the average potato farmer had a 21 percent decrease in toxicity units!

4. Have students share reactions to the methods used by the potato growers in Wisconsin. At this point, students should realize that sorting out which pesticides are "better" than others is a complicated business but that real people are developing and applying methods of doing so with a goal of reducing the harmful environmental effects from pesticide use.

Part C: Tying It All Together

1. Explain that Wisconsin is the third-largest producer of potatoes in the United States (other large producers are Idaho, Maine, and Washington) and that two-thirds of potatoes grown in Wisconsin are turned into french fries, potato chips, and other processed potatoes. Also explain that the students are going to find out more about what some Wisconsin farmers have been doing to help the environment.

2. Pass out copies of the "Fields of Change" article and the "Fields of Change Question Sheet." Tell students to read the article and to use it to answer the questions on the sheet. After students have had a chance to complete the reading and question sheet, go over the results. You might refer to the student pages with the answers provided.

(Optional: pass out copies of these student pages.). What did students think of the changes the Wallendals made? Were students surprised by anything that they did? Did the changes they made seem like actions "any farmer" should be able to take? What was risky about what the Wallendals did?

3. Hold up a large potato, tell the students it is a regular potato, and ask them how much they think it would cost in the store. Arrive at a price everyone can agree on, and write it on the board. Then hold up a second similarly sized potato, and tell the group to pretend it is a Wallendal potato. Divide the class into groups of four or five students, and tell them that they must decide in their group how much they would be willing to pay for the Wallendal potato. The price they come up with may be more than, less than, or the same as the cost of the first potato, but the students must have a precise dollar figure and an explanation for that price. If the students are having trouble getting started, you might have them think about what aspects of the way in which the Wallendal potato was grown make it seem like it should be more or less expensive. If they are still having trouble, you might have them think about each of these points:

- By using fewer pesticides, the Wallendals have decreased the amount of pollutants flowing into nearby streams and leaching into groundwater.
- By using fewer pesticides, the Wallendals have increased the abundance of beneficial insects and other organisms on their farm.
- By using fewer pesticides, the Wallendals have decreased the harm they do to nontarget species, such as bees, birds, and fish in nearby streams.
- By using fewer pesticides, the Wallendals have increased the amount of time they must spend monitoring their fields.

4. Have members of each group present the price they arrived at and their reasons for that price. Have them share their views on pesticide-reduced potatoes. Does it make sense to them to try to reduce the use of pesticides? (Opinions will vary.) What are the tradeoffs? (Fewer pesticides would mean a healthier environment for people and other living things; fewer pesticides could also mean less-abundant—and, therefore, more expensive—food; fewer pesticides could be more work for farmers—and potentially greater financial risk.) Be sure that students understand that it is very difficult to assign economic values to things such as clean water and beneficial species. Methods are beginning to be developed, however, that can help put a value on nature's services. These include bioeconomic analysis, non-market valuation surveys, and Payment-for-Ecosystem-Services (PES) programs and proxies.[17]

5. One problem that potato farmers face and that was highlighted in the "Fields of Change" article is the marketability of the pesticide-reduced potatoes. Ask the students if they would be willing to buy pesticide-reduced potatoes. Do they think other people would be willing to buy the potatoes? How could the students convince people to buy potatoes grown with fewer pesticides over "regular" potatoes? Then divide the group into smaller teams and explain that they have to come up with a marketing campaign to promote the pesticide-reduced potatoes.

Enrichments

- Have students investigate the availability of pesticide-reduced or organically grown products in their community. Some of the questions they might try to answer include these: What types of organically grown fruits and vegetables are available? Are they easy to find in the store? How do prices between the organic and the regular fruits and vegetables compare? Are chips and other processed foods available that use pesticide-free ingredients? How do supermarkets and other stores decide what types of produce to offer? What factors are important to consumers in your area when they purchase fruits and vegetables?

- Have students conduct a pesticide inventory of their own homes or the school or both. Students should inventory what kind of products are in the house or building (including their toxicity), how they are stored, and how the empty containers are disposed of. Students might also note the product labels for instructions about proper storage and disposal and then keep track of how well what they, their parents, or school personnel are doing is in keeping with those instructions.

- Have students research how hazardous materials such as toxic chemicals get disposed of in their community. Are there hazardous materials collection days or sites? How frequently can people drop off those kinds of materials? What kinds of materials get dropped off? How much do those sites collect each month? What happens to the materials the sites collect? How knowledgeable are people in their community about the use and disposal of hazardous materials?

Pesticide Resources for Educators and Students

- The office of pesticide programs of the U.S. Environmental Protection Agency (EPA) has a website at www.epa.gov/pesticides. It provides information on pesticide safety, pesticide fact sheets, compliance, and more.

- The National Pesticide Information Center (NPIC), which is a cooperative effort of Oregon State University and the EPA has a website at www.npic.orst.edu/. It provides general information about pesticides, as well as detailed information on specific pesticides.

- Extoxnet is a cooperative effort of the University of California–Davis, Oregon State University, Michigan State University, Cornell University, and University of Idaho. Extoxnet's website is at extoxnet.orst.edu/. Its goal is to provide unbiased information in a form understandable by the nonexpert. Pesticide Information Profiles on specific pesticides are provided.

- Ware, George W. *Pesticide Book*. (Willoughby, Ohio: Meister Publishing Company, 2004). This book provides in-depth information about pesticides as it examines pesticide properties; their use and chemistry; and their proper handling, storage, and disposal.

- Briggs, Shirley A., and Rachel Carson Council Inc. *Basic Guide to Pesticides: Their Characteristics and Hazards*. (Washington, DC: Taylor & Francis, Inc, 1992). This book provides physical properties for approximately 700 pesticides, as well as information on the constituents, characteristics, health effects, and environmental effects of pesticides.

Endnotes

1 U.S. Environmental Protection Agency. "What Is a Pesticide?" http://www.epa.gov/pesticides/ about (accessed on February 1, 2007).
2 Ibid.
3 U.S. Environmental Protection Agency. "Restricted Use Products Report." http://www.epa.gov/opprd001/rup/ (accessed on February 1, 2007).
4 Cornell University Cooperative Extension. "Toxicity of Pesticides." http://pmep.cce.cornell.edu/facts-slides-self/core-tutorial/module04/index.html (accessed on February 1, 2007).
5 Ibid.
6 U.S. Environmental Protection Agency. "Persistent Organic Pollutants (POPs)." http://www.epa.gov/oppfead1/international/pops.htm (accessed on February 1, 2007).
7 Ibid.
8 U.S. Environmental Protection Agency. "Persistent Organic Pollutants: A Global Issue, A Global Response." http://www.epa.gov/international/toxics/pop.htm#pops (accessed on February 1, 2007).
9 Texas Environmental Profiles. "Pesticides in the United States." http://www.texasep.org/html/ pes/pes_1usa.html (accessed on February 2, 2007).
10 Ibid.
11 Rollins, Dale, Thomas Fuchs, Wayne Hanselka, and Judy Winn. "Reducing Pesticide Risks to Wildlife." http://texnat.tamu.edu/publications/ B-5095.htm (accessed on February 2, 2007).

12 Defenders of Wildlife. "The Dangers of Pesticides to Wildlife." http://www.beyondpesticides.org/ pesticide-freelawns/resources/DWDangers_Pesticides_Wildlife.pdf (accessed on February 2, 2007).
13 Ibid.
14 U.S. Environmental Protection Agency. "Pesticides Industry Sales and Usage." http://www.epa.gov/oppbead1/pestsales/95pestsales/market_estimates1995.pdf (accessed on February 2, 2007).
15 Wisconsin Healthy Grown Potatoes. "Consumers—Healthy Grown Potatoes." http://www.healthygrown.com/interior_page.cfm?PageID=1 (accessed on February 2, 2007).
16 WWF/WPVGA/UW Collaboration. "Companion Documentation for the Eco-Potato Standards." http://209.85.165.104/search?q=cache:aCL4ZOxICyAJ:128.104.239.6/bioipm/farmland_project/labeling/policypaper.22602.pdf+Companion+Document+for+the+eco-potato+standards&hl=en&ct=clnk&cd=1&gl=us (accessed on February 2, 2007).
17 Resources for the Future. 2007. *Resources: Putting a Value on Nature's Services* 165 (Spring 2007): 10–20. http://www.rff.org/rff/Documents/RFF-Resources-165.pdf (accessed on June 18, 2007).

Insecticide Information Sheet

Insecticide	Toxicological Effects	Ecological Effects	Fate in the Environment
Endosulfan			
Methamidophos			
Imidacloprid			
Esfenvalerate			
Dimethoate			

Insecticide Information Sheet with Answers

Insecticide	Toxicological Effects	Ecological Effects	Fate in the Environment
Endosulfan	Toxicity Class I—highly toxic through the oral and dermal routes; only slightly toxic through inhalation; may cause mutagenic effects in humans if exposure is great enough.	Highly to moderately toxic to bird species; very highly toxic to four fish species and to both of the aquatic invertebrates studied. (It is moderately toxic to bees and is relatively nontoxic to beneficial insects such as parasitic wasps, lady bird beetles, and some mites.)	Moderately persistent in the soil environment with a reported average field half-life of 50 days. (Large amounts of endosulfan can be found in surface water near areas of application. It has also been found in surface water throughout the country at very low concentrations.)
Methamidophos	Toxicity Class I—highly toxic through the oral, dermal, and inhalation routes of exposure; reduced sperm count and reduced sperm viability observed in humans; may be weakly mutagenic.	Very toxic to birds; toxic to aquatic organisms; toxic to bees.	In aerobic soils, half-life of 1.9 to 12 days; half-life in water of 309 days at pH 5.0, 27 days at pH 7.0, and 3 days at pH 9.0.
Imidacloprid	Toxicity Class II and Class III—moderately toxic; may be weakly mutagenic; considered to be of minimal carcinogenic risk.	Toxic to upland game birds; moderately low toxicity to fish; highly toxic to bees if used as a foliar application, especially during flowering, but not considered a hazard to bees when used as a seed treatment.	Half-life in soil of 48–190 days; half-life in water that is much greater than 31 days.

Insecticide Information Sheet with Answers (continued)

Insecticide	Toxicological Effects	Ecological Effects	Fate in the Environment
Esfenvalerate	Toxicity Class II—moderately toxic compound through the oral route; slightly toxic through the dermal route; practically nontoxic through inhalation.	Slightly toxic to birds; very highly toxic to fish and aquatic invertebrates; highly toxic to bees.	Moderately persistent with a half-life ranging from about 15 days to 3 months; half-life in water of about 21 days.
Dimethoate	Toxicity Class II—moderately toxic by ingestion, inhalation, and dermal absorption.	Moderately to very highly toxic to birds; moderately toxic to fish; highly toxic to honeybees.	Low persistence in the soil (half-life of 20 days); half-life in raw river water of 8 days.

Herbicide Information Sheet

Herbicide	Toxicological Effects	Ecological Effects	Fate in the Environment
Linuron			
Glyphosate			
Metribuzin			
Paraquat			
Metolachlor			

Herbicide Information Sheet with Answers

Herbicide	Toxicological Effects	Ecological Effects	Fate in the Environment
Linuron	Toxicity Class III—slight toxicity by ingestion; slight toxicity by inhalation; either non-mutagenic or slightly mutagenic.	Slightly toxic to birds; slightly toxic to fish and aquatic invertebrate species; nontoxic to bees.	Moderately persistent in soils, with a field half-life of 30 to 150 days in various soils and under various conditions; slightly to moderately soluble in water; not readily broken down in water.
Glyphosate	Toxicity Class II—practically nontoxic by ingestion; practically nontoxic by skin exposure. (Some formulations may show high acute inhalation toxicity.)	Slightly toxic to wild birds; practically nontoxic to fish; may be slightly toxic to aquatic invertebrates; nontoxic to honeybees.	Moderately persistent in soil, with an estimated average half-life of 47 days; half-life in pond water that ranges from 12 days to 10 weeks.
Metribuzin	Toxicity Class III—slightly toxic through the oral route; practically nontoxic dermally; moderate toxicity through the inhalation route.	Moderately to slightly toxic to birds; slightly toxic to fish; nontoxic to bees.	Moderate persistence in the soil environment (soil half-life of 30 to 120 days); half-life in pond water of approximately 7 days.

Herbicide Information Sheet with Answers (continued)

Herbicide	Toxicological Effects	Ecological Effects	Fate in the Environment
Paraquat	Toxicity Class I—highly toxic through ingestion; moderate toxicity through the dermal route. (Persons with lung problems may be at increased risk from exposure. Many cases of illness or death have been reported in humans. Evidence regarding carcinogenic effects of paraquat is inconclusive.)	Moderately toxic to birds; slightly to moderately toxic to many species of aquatic life; nontoxic to honeybees.	Highly persistent in the soil environment, with reported field half-life of greater than 1,000 days.
Metolachlor	Toxicity Class III—slightly toxic through ingestion; slightly to practically nontoxic by skin exposure; slight toxicity through inhalation.	Slightly to practically nontoxic to birds; moderately toxic to both cold-water and warm-water fish, including rainbow trout, carp, and bluegill sunfish; nontoxic to bees.	Moderately persistent in the soil (half-life of 15 to 70 days); highly persistent in water over a wide range of water acidity.

Fungicide Information Sheet

Fungicide	Toxicological Effects	Ecological Effects	Fate in the Environment
Dimethomorph			
Chlorothalonil			
Maneb			
Mancozeb			
Metiram			

Fungicide Information Sheet with Answers

Fungicide	Toxicological Effects	Ecological Effects	Fate in the Environment
Dimethomorph	Toxicity Class III—slightly toxic; slightly toxic to mammals.	Practically nontoxic to birds; moderately toxic to fish; slightly toxic to aquatic invertebrates, algae, and bacteria; nontoxic to bees.	Low soil mobility and low leaching potential.
Chlorothalonil	Toxicity Class II—moderately toxic; slightly toxic to mammals, but can cause severe eye and skin irritation.	Practically nontoxic to birds; highly toxic to fish, aquatic invertebrates, and marine organisms; nontoxic to bees.	Moderately persistent; in aerobic soils, half-life of from 1 to 3 months.
Maneb	Toxicity Class IV—practically nontoxic by ingestion; through the dermal route, is slightly toxic; very high level of exposure necessary to cause reproductive effects in humans; that level of exposure not likely under normal circumstances.	Practically nontoxic to birds; highly toxic to fish and aquatic species; may be toxic to livestock; not thought to be toxic to bees.	Low persistence (with a reported field half-life of 12 to 36 days), but readily transformed into ethylenethiourea, which is more persistent; would degrade completely within 1 hour under anaerobic aquatic conditions.

Fungicide Information Sheet with Answers (continued)

Fungicide	Toxicological Effects	Ecological Effects	Fate in the Environment
Mancozeb	Toxicity Class IV—practically nontoxic through the oral and dermal routes; metabolite that produced birth defects and cancer in experimental animals; either not mutagenic or weakly mutagenic; carcinogenic potential of mancozeb not currently known.	Slightly toxic to birds; moderately to highly toxic to fish and aquatic organisms; not toxic to honeybees.	Of low soil persistence, with a reported field half-life of 1 to 7 days; not poisonous to plants; degrades in water with a half-life of 1 to 2 days.
Metiram	Toxicity Class IV—practically nontoxic when ingested; slightly toxic through the dermal route; slightly toxic through inhalation route. (Ethylenethiourea, a contaminant and a breakdown product of metiram has been shown to cause birth defects and cancer in experimental animals.)	Slightly toxic to birds; slightly to moderately toxic to fish; practically nontoxic to bees.	Of low persistence and strongly bound to most soils; very rapid breakdown in water.

Pota-pourri

1/3 . . . . . .Fraction of U.S. potatoes grown in Wisconsin.

60 percent . . . . . .Percentage of Wisconsin potatoes turned into potato chips, french fries, or other processed potato foods.

100 . . . . . .Pounds of potatoes the average American eats each year.

80,000 . . . . . .Acres used in Wisconsin to grow potatoes.

789 million . . . . . .Pounds of pesticide used for agriculture in the United States in 1994.

5th . . . . . .Potatoes rank fifth in overall pesticide use after corn, soybeans, cotton, and grapes.

67 million . . . . . .Birds killed each year by pesticides.

74 percent . . . . . .The percentage of all U.S. households using some form of pesticide in 1994.

Ranking Pesticides Question Sheet

Using the information you gathered about the five different pesticides that your team researched, discuss these questions as a group. Record your answers.

1. Which one would you consider the most toxic and least toxic according to **toxicological effects**?

2. Which one would you consider the most toxic and least toxic according to **ecological effects**?

3. Which one would you consider the most toxic and least toxic according to **fate in the environment**?

4. If you had to advise farmers about which of the five pesticides your group researched is the "worst" to use in terms of its effects on people and the environment, which would you choose? Why? What about the "best" one to use? Why?

5. Was it easy to establish the ranking for Question 4? Why or why not?

Fields of Change

by Jennifer Curtis

Adapted with permission from *Fields of Change, A New Crop of American Farmers Finds Alternatives to Pesticides*, Natural Resources Defense Council, July 1998.

John and Andrew Wallendal; their father, Peter; and their brother-in-law, Robert Stodola, grow vegetables on 3,225 acres in the Central Sands region of Wisconsin, north of Madison. The area has sandy soils that were turned into one of the most productive vegetable-producing regions of the country through the invention of irrigation equipment and manufactured fertilizers. The Wallendals' number one crop is potatoes—and they grow a lot of them. Every year, they harvest 39 million pounds of potatoes, most of which are sold and made into french fries.

Besides being characterized by sandy soils, the Central Sands region also has a shallow *groundwater aquifer*. That term means that there is a lot of water not far below the surface of the soil—water that can be tapped by wells and used for people's homes, businesses, and farms. But because the groundwater is close to the surface and the soil is sandy, chemicals such as fertilizers and pesticides that people spread on the ground can easily percolate down into the groundwater.

Concerned about contaminating the underground aquifer with pesticides and fertilizers, the Wallendals wanted to change the way they farmed. They also wanted to help prevent soil erosion on their property. But they wanted—and needed—to address those concerns while still producing a high yielding, top-quality crop. They have been so successful that they have earned recognition throughout the industry. From 1991 through 1996, the Wallendals' farm was awarded six top grower awards for the central states region for outstanding potato quality. And in 1997, the Wallendals were recognized nationally by the National Potato Council for their efforts to practice "Environmental Stewardship." Here is how they did it.

Finding New Ways to Fight Old Foes

The Wallendals started out farming in the conventional way, relying extensively on the use of pesticides and synthetic fertilizers. But around 1990, the family members decided they wanted to take a more integrated, holistic approach to growing vegetables. One of the events that made them want to change what they were doing was the ban of an acutely toxic insecticide called Temik (also called *aldicarb*)

Rose aphid

Until 1987, John used Temik every year at planting. It controlled all three of the worst potato pests: Colorado potato beetles, potato leafhoppers, and aphids. It also left residues on plants—

Fields of Change (continued)

residues that could harm people who ate the food. When Temik was pulled off the market because of such health concerns, the Wallendals had to figure out a way to combat all three potato pests using other tactics.

For 18 years, the Wallendals had been using professional Integrated Pest Management (IPM) services to monitor pest levels in their fields. The IPM professionals checked the fields according to a schedule set out before the beginning of the season. After Temik was pulled from the market, the Wallendals hired a second in-house person to scout for insect population levels in fields on an as-needed rather than a prescheduled basis. In addition, John's brother-in-law, Robert, began devoting most of his time to pest management issues. This more intensive scouting regimen enabled the Wallendals to make more informed decisions about whether and when to spray different pesticides to combat the different pests. And their greater scrutiny ended by reducing the number of times the Wallendals needed to spray, as well as by reducing the total amount of pesticides they sprayed. Between 1990 and 1998, the Wallendals went from spreading insecticides four times during the season to spreading insecticides just once. They reduced their insecticide use by 75 percent.

In recent years, Temik has been allowed back on the market for use on potatoes. John is amazed that some states are welcoming it back. "We're glad to see we can manage without the use of a chemical that presented such a problem for our groundwater and health of our workers," John remarked.

Fighting Fungus with WISDOM

Insects are not the only pests that potato farmers such as the Wallendals face. One of the worst threats to potato production are disease-causing fungi that can rot potato leaves, stems, and tubers if conditions are right. The fungi—referred to as early and late season *blights*—live in the soil and can become airborne and travel great distances. (The infamous potato famines in Ireland were largely caused by blight.)

The Wallendals still use fungicides to control blight outbreaks when they occur; over the years, however, they have fine-tuned ways to prevent blight infections. The Wallendals buy potato seeds that are disease resistant, and they make sure that the seeds themselves are not already infected. They also rotate their crops on a four-year cycle to reduce the buildup of disease organisms in the soil. They grow potatoes in any given field only once every four years, growing another vegetable crop that is not susceptible to the same potato diseases, such as sweet corn or snap beans, in the alternate years.

The Wallendals have also converted their irrigation system so that it is now computer-controlled. This change enables them to time their irrigations and to limit the lengths of time that plant leaves are wet. It also helps reduce the infection rate and potency of fungal blights. They can preprogram irrigations to occur in the evening, when there's less evaporative water loss than in the heat of the day. This timing helps save electrical power and money.

In 1986, the University of Wisconsin approached the Wallendals and several other farm operators to join a six-year research project that is designed to test how multiple IPM strategies, including crop rotations and biological control, work together to control pests over time. The Wallendals donated 24 acres of irrigated crop land, equipment, and management; the university provided technical and data collection expertise. Money to help fund the study was also provided by the Wisconsin Potato and Vegetable Growers Association and the U.S. Department of Agriculture.

The most significant outcome of the project was the development of a computer disease forecast-

Fields of Change (continued)

ing system called *WISDOM*. The Wallendals enter certain data into the computer, including weather conditions and the cultural practices that they use. Cultural practices include when and how they plant, the types of seed they use, their crop rotation cycle, and so forth. Then WISDOM predicts the appearance of early blight and late blight. This system has allowed the Wallendals to know exactly when to first apply fungicides to keep disease pressure to a minimum and how to stretch out the time between fungicide applications. Between 1987 and 1995, WISDOM helped the Wallendals cut their fungicide use for early and late blight by 50 percent. In 1996, however, a severe late blight pandemic hit the area, and the Wallendals had to act quickly to save the crop; they increased their fungicide use to conventional levels. The Wallendals believe that, averaged over the 10-year period between 1987 and 1996, they cut the amount of fungicides they spread by one-third.

Potato blight

The Wallendals are proud to have been involved in *WISDOM*'s development and are even more enthusiastic about the cooperative multidisciplinary nature of the project. John notes, "Partnerships between farmers and university researchers not only are instructional, but also have a huge capacity to generate positive changes in agricultural systems." *WISDOM* is now being promoted throughout the Wisconsin potato industry; it has been particularly helpful for disease management.

Changing the War on Weeds

Not too long ago, the Wallendals used a "moldboard" plow as the main way to cultivate the soil and to eliminate weeds. This type of plow churns, or tills, the top 10 inches of soil. Such deep tilling is highly disruptive to the integrity of the soil and makes the soil vulnerable to erosion. In recent years, the Wallendals have switched to a minimum tillage method. The Wallendals' minimum tillage method involves tilling in such a way that the crop residue remains on the soil surface and the soil stays in its original vertical position. They estimate that only 1 percent of the soil is displaced using this method.

Another important aspect of the Wallendals' weed management program is a fall planting of rye grass as a winter cover crop. The Wallendals have noticed that weed infestations are less severe when they plant potatoes after a winter of rye grass. They believe this change is because of allelopathy, the chemical influence of one plant on another. The rye plant, because of a biochemical interaction in the soil, is able to inhibit the growth of certain weed species. This allelopathic effect can also be harmful to potato plants, so the Wallendals kill the rye grass with the herbicide Roundup® (*glyphosate*) before they plant potatoes so they can stop biochemical interaction to the soil. They allow the rye grass to remain in the ground after it has been killed; thus, the rye helps prevent soil erosion and makes it easier for water to soak into the soil.

The Wallendals still rely on herbicides for weed control, and although they have only minimally reduced such use, they have switched to compounds they believe are less hazardous. In particular, they have replaced the use of Dual® (*metolachlor*) with Roundup®.

Fields of Change (continued)

Giving Plants What They Need

To grow, potatoes and other plants need nutrients. By using fertilizers, farmers such as the Wallendals provide nutrients that the plants need. But too much fertilizer at the wrong time can mean the fertilizer ends up in groundwater rather than in the plants. The Wallendals have taken significant steps to improve nutrient management and to reduce their use of fertilizers.

John, who worked as a medical technician for eight years before returning to farming, has set up a testing laboratory in the family's farm office. Family members test plant tissue using a chlorophyll meter, which enables them to determine what nutrients the plants need and in what amounts. Instead of having to send tissue samples out to be tested and waiting at least a week for the results, John is able to have results within one to two hours.

When the family first set up the lab and started testing plant samples, John realized that 50 percent of the fertilizers being applied to the soil were not being used by the potato plants. That meant the Wallendals were wasting fertilizers—fertilizer that most likely ended up leaching through the soils into groundwater. Now, instead of applying all the fertilizer early in the growing season when the fertilizer is most vulnerable to leaching, the Wallendals wait and apply only as much as the plant needs. In the past eight years, this practice has allowed them to make a 5 percent reduction in high-salt fertilizers, particularly potash. John points out, "Although the reduction in volume is not particularly significant, we have vastly improved our timing so that all the nutrients we put in the field are used by the plant. This timing, more than anything, has the greatest effect on reducing water contamination."

Tissue testing helps the Wallendals fight plant diseases. Plants have natural defenses against disease, but when the plants lack nutrients, those defenses weaken. By putting a nutrient program in place throughout the growing season, the Wallendals are able to minimize outbreaks of diseases such as early blight.

In the future, John hopes they will be able to work with a dairy farm so that he can have a constant and consistent supply of cow manure to use as a source of nitrogen and organic matter for his soils. He is even considering diversifying their farm's operation by adding dairy cows. John says, "There is the potential for a beneficial and symbiotic relationship between dairy cows and vegetable production. The crop residue we generate can be fed to cows, and the waste they generate is a valuable input for vegetables. This is the way it was always done in the old days, except on much smaller farms." The major stumbling block for making this change right now is that for their scale of vegetable production, the Wallendals would need 2,000 cows. "This [change] would be a capital intensive and risky endeavor, and right now it would mean less time with our families," says John.

Yields and Quality

The Wallendals have consistently attained yields that are comparable to the yields they achieved when they farmed using conventional methods. Their yields equal the countywide average. The

Fields of Change (continued)

Wallendals have also consistently met or exceeded the quality standards established by the potato processing industry.

Potatoes sold on the fresh market, however, must meet a higher standard than those made into french fries. According to John, "The consumer wants a regular blocky unblemished potato from the fresh market, thus we must choose varieties that are based on those characteristics. Unfortunately, those potato varieties have not been bred to be extremely resistant to diseases, which makes it difficult for us to reduce chemical and fertilizer use. If consumers were less picky and could accept slightly blemished, yet nutritionally sound, food on occasion, then we could use more of our sustainable disease management techniques to grow potatoes for the fresh market."

Production Costs

By reducing their use of pesticides and fertilizers, the Wallendals have lowered their total cost of production by 9 percent. The amount they spend on chemical inputs has gone down 39 percent. The Wallendals show a net gain of $20 per acre because of a reduction in purchased inputs. Although these are real gains, they are at least partially offset when the value of the increased management time is accounted for.

Concerns and Recommendations

The Wallendals would like to continue to reduce their pesticide use. John speaks adamantly that if this reduction is to occur, they need much more support in the marketplace. "We sell our products to internationally based processors and marketing groups who are inherently risk averse. If consumers don't have a means of choosing IPM-grown potatoes, then they can't demonstrate their support, which is what is needed to change the marketing habits of processors. We have tried to market our potatoes ourselves, but this is an area of expertise we do not have right now."

In addition to the need for national processors that are willing to market an IPM-based product, John identifies the need for research devoted to figuring out how farms of his scale can convert to more sustainable practices.

John says, "I think there are two reasons farmers don't adopt more sustainable practices. First, it is a big risk. Farming is not only a lifestyle but also a livelihood. And, second, it is human nature to resist change unless that change is your own idea. Farmers are fiercely independent. To see overall changes to the agricultural industry will require a great deal of patience."

The Wallendals attribute their success to their willingness to embrace change and to work cooperatively together. John notes that each of the family partners has different strengths, and balancing their different instincts has been critical to their success. They also give credit to the University of Wisconsin Extension system for focusing on multidisciplinary research that addresses on-farm concerns.

Fields of Change Question Sheet

Read the "Fields of Change" article, and use it to answer the following questions:

1. What factors motivated the Wallendals to change their farming practices?

2. What changes did the Wallendals make to their farming methods and for what purpose? List as many as you can.

3. Were the Wallendals able to reduce their use of insecticides? Fungicides? By how much?

4. How do the potatoes the Wallendals raise compare to potatoes grown by more conventional methods? How do their costs of production compare?

Fields of Change Question Sheet (continued)

5. What obstacles do the Wallendals see to reducing their pesticide use even further?

6. What obstacles do the Wallendals see to other farmers adopting methods that use fewer pesticides? What tactics or programs would you suggest to encourage farmers to adopt new methods?

7. What do you think about what the Wallendals have accomplished? What advantages and disadvantages do you see in their farming methods?

8. What do you think about the notion of fresh potatoes needing to be blocky and unblemished? Would you be willing to settle for less than perfect fresh potatoes? Why or why not?

Answers to Fields of Change Questions

1. What factors motivated the Wallendals to change their farming practices?

Answer: Concerns about groundwater contamination and soil erosion, prohibition of a pesticide they had relied on heavily, and the need to do things differently.

2. What changes did the Wallendals make to their farming methods and for what purpose? List as many as you can.

Answer: Hired second in-house Integrated Pest Management (IPM) specialist to monitor insect population levels in fields, as needed; purchased potato seeds that are resistant to diseases; made sure seeds weren't infected; rotated crops every four years to reduce buildup of disease organisms in soil; switched to computer-controlled irrigation system to time irrigation so it limits leaf wetness and, therefore, reduces infection rate and potency of fungal blights; joined University of Wisconsin's disease prediction project, which helped them know when to apply fungicide; switched to minimum tillage method to reduce soil erosion; planted rye grass as winter cover and then killed the grass with Roundup®; replaced herbicides with less-toxic alternatives; set up tissue-testing laboratory to determine what nutrients are needed when, which saves on fertilizer, and which helps combat disease.

3. Were the Wallendals able to reduce their use of insecticides? Fungicides? By how much?

Answer: Yes; insecticides—75%; fungicides—50%.

4. How do the potatoes the Wallendals raise compare to potatoes grown by more conventional methods? How do their costs of production compare?

Answer: Yields that are comparable to county-wide average; quality that meets or exceeds industry standards for processed potatoes; potatoes that are not consistent enough for fresh marketing; fact that they saved $20/acre.

5. What obstacles do the Wallendals see to reducing their pesticide use even further?

Answer: Need national processors willing to market IPM-grown potatoes; need more research on how farms of this scale can adopt more sustainable practices.

6. What obstacles do the Wallendals see to other farmers adopting methods that use fewer pesticides? What tactics or programs would you suggest to encourage farmers to adopt new methods?

Answer: High risk, farmers who always resist change; get support from local universities and Agriculture Extension Offices.

7. What do you think about what the Wallendals have accomplished? What advantages and disadvantages do you see in their farming methods?

Answer: Student answers will vary.

8. What do you think about the notion of fresh potatoes needing to be blocky and unblemished? Would you be willing to settle for less than perfect fresh potatoes? Why or why not?

Answer: Student answers will vary.

Conceptual Framework

Theme: Diversity

1.0 Throughout the world, there is a great diversity of habitats, organisms, societies, technologies, and cultures.

Diversity in Environments

1.1 Biodiversity results from the interaction of living and nonliving environmental components such as air, water, climate, and geologic features.
1.2 Forests, as well as other ecosystems, contain numerous habitats that support diverse populations of organisms.
1.3 The Earth's atmosphere, water, soil, climate, and geology vary from region to region, thus creating a wide diversity of biological communities.

Diversity of Resources and Technologies

1.4 Humans use tools and technologies to adapt and alter environments and resources to meet their physical, social, and cultural needs.
1.5 Technologies vary from simple hand tools to large-scale and complex machinery, mechanisms, and systems.
1.6 Successful technologies are those that are appropriate to the efficient and sustainable use of resources, and to the preservation and enhancement of environmental quality.

Diversity Among and Within Societies and Cultures

1.7 Human societies vary greatly and inhabit many land forms and climates throughout the world.
1.8 Humans throughout the world create differing social, cultural, and economic systems and organizations to help them meet their physical and spiritual needs.
1.9 The standard of living of various peoples throughout the world is dependent on environmental quality; the availability, utilization, and distribution of resources; the government; and culture of its inhabitants.
1.10 Natural beauty, as experienced in forests and other habitats, enhances the quality of human life by providing artistic and spiritual inspiration, as well as recreational and intellectual opportunities.

Theme: Interrelationships

2.0 The ecological, technological, and socio-cultural systems are interactive and interdependent.

Environmental Interrelationships

2.1 Organisms are interdependent, and depend on nonliving components of the Earth.
2.2 Altering the environment affects all life forms, including humans, and the interrelationships that link them.
2.3 Organisms adapt to changes in the environment according to the genetic and behavioral capacity of their species.

Resource and Technological Interrelationships

2.4 Resource management technologies interact and influence environmental quality; the acquisition, extraction, and transportation of natural resources; all life forms; and each other.
2.5 While technological advances decrease the incidence of disease and death, the ever-increasing world population is placing heavy demands on the finite resources of the Earth.
2.6 International cooperation directed toward conserving resources and protecting environmental quality is beneficial to human health and the well-being of other life forms.
2.7 By reducing waste and recycling materials, individuals and societies can extend the value and utility of resources and also promote environmental quality.

Societal and Cultural Interrelationships

2.8 Human societies and cultures throughout the world interact with each other and affect natural systems upon which they depend.
2.9 The quantity and quality of resources and their use—or misuse—by humans affect the standard of living of societies.
2.10 Cultural and societal perspectives influence the attitudes, beliefs, and biases of people toward the use of resources and environmental protection.

2.11 All humans consume products and thereby affect the availability of renewable and nonrenewable natural resources.
2.12 The extracting, processing, transporting, and marketing of natural resources provide employment opportunities for many people.

Theme: Systems

3.0 Environmental, technological, and social systems are interconnected and interacting.

Environmental Systems

3.1 In biological systems, energy flows and materials continually cycle in predictable and measurable patterns.
3.2 Plant and animal populations exhibit interrelated cycles of growth and decline.
3.3 Pollutants are harmful by-products of human and natural systems which can enter ecosystems in various ways.
3.4 Ecosystems possess measurable indicators of environmental health.

Resource Management and Technological Systems

3.5 The application of scientific knowledge and technological systems can have positive or negative effects on the environment.
3.6 Resource management and technological systems can help societies meet, within limits, the needs of a growing human population.
3.7 Conservation technology enables humans to maintain and extend the productivity of vital resources.

Systems in Society and Culture

3.8 Most cultures have beliefs, values, and traditions that shape human interactions with the environment and its resources.
3.9 In democratic societies, citizens have a voice in shaping resource and environmental management policies. They also share in the responsibility of conserving resources and behaving in an environmentally responsible manner.
3.10 In democratic societies, individuals and groups, working through governmental channels, can influence the way public and private lands and resources are managed.
3.11 Effective citizen involvement in the environmental decision-making process involves a careful study of all sides of the issues, along with the ability to differentiate between honest, factually accurate information and propaganda.

Theme: Structure and Scale

4.0 Technologies, societal institutions, and components of natural and human-built environments vary in structure and scale.

Structures and Scale in Environments

4.1 Populations of organisms exhibit variations in size and structure as a result of their adaptation to their habitats.
4.2 The structure and scale of an ecosystem are influenced by factors such as soil type, climate, availability of water, and human activities.
4.3 When the Earth is studied as an interacting ecological system, every action, regardless of its scale, affects the biosphere in some way.

Structure and Scale in Resources and Technology

4.4 Technologies vary in size, structure, and complexity and in their positive and negative effects on the environment.
4.5 Conservation and management technologies, when appropriately applied to the use or preservation of natural resources, can enhance and extend the usefulness of the resource, as well as the quality of the environment.
4.6 Human-built environments, if planned, constructed, and landscaped to be compatible with the environment in which they will be located, can conserve resources, enhance environmental quality, and promote the comfort and well-being of those who will live within them.
4.7 International cooperation on resource management and environmental improvement programs can be beneficial to people in many parts of the world.

Structure and Scale in Societies and Cultures

4.8 The structure and scale of the natural resources in a given area shape the economy upon which the society and its culture is based. Cultural structures and actions affect the management of resources and environmental quality.
4.9 Governmental, social, and cultural structures and actions affect the management of resources and environmental quality.
4.10 Demographics influence environmental quality, government policy, and resource use.

Theme: Patterns of Change

5.0 Structure and systems change over various periods of time.

Patterns of Change in the Environment

5.1 Organisms change throughout their lifetimes. Species of organisms change over long periods of time.
5.2 Although species become extinct naturally, the increasing number of extinctions in recent history may be linked to the rapid increase in human population.
5.3 As organisms go through their life cycle of growth, maturity, decline, and death, their role in the ecosystem also changes.
5.4 Ecosystems change over time through patterns of growth and succession. They are also affected by other phenomena such as disease, insects, fire, weather, climate, and human intervention.

Patterns of Change in Resource and Technologies

5.5 Our increasing knowledge of the Earth's ecosystems influences strategies used for resource management and environmental stewardship.
5.6 Technologies that are developed to meet the needs of an increasing world population should also be environmentally sound.
5.7 To be most effective, new technologies require well-informed and highly skilled workers.

Patterns of Change in Society and Culture

5.8 Governments change and evolve over the years. Such changes affect the lives of its citizens, as well as resource management and environmental policies.
5.9 Consumers "drive" the marketplace with their demands for goods and services. Such demands shift with time and may have positive or negative effects on the resource base and environmental quality.
5.10 Industries usually respond to consumer demand for recyclable, recycled, or otherwise environmentally friendly products.
5.11 Leisure and recreational pursuits can have an impact on forests and other resource-producing areas.
5.12 Increased public knowledge of the environment and the need for conservation of natural resources have resulted in lifestyle changes in many cultures.

Correlation to Science and Social Studies Standards

The ***National Science Education Standards***, published by the National Research Council in 1996, were developed to provide criteria against which we can measure the quality of science education. Using these guidelines, the activities in this module address the following science education content standards for grades 9–12:

- Unifying Concepts and Processes
  - Systems, Order, and Organization
  - Evidence, Models, and Explanation
- Standard A: Science as Inquiry
  - Understandings about Scientific Inquiry
- Standard C: Life Science
  - The Interdependence of Organisms
  - The Behavior of Organisms
- Standard E: Science and Technology
  - Understandings about Science and Technology
- Standard F: Science in Personal and Social Perspectives
  - Natural Resources
  - Environmental Quality
  - Natural and Human-Induced Hazards
  - Science and Technology in Local, National, and Global Challenges
- History and Nature of Science
  - Science as a Human Endeavor

The ***Curriculum Standards for Social Studies***, published by the National Council for the Social Studies in 1994, were developed to provide a set of criteria against which we can measure the quality of social studies education. Using these guidelines, the activities in this module address the following social studies performance expectations for grades 9–12:

- Strand III: People, Places, & Environment
  - h. examine, interpret, and analyze physical and cultural patterns and their interactions, such as land use, settlement patterns, cultural transmission of customs and ideas, and ecosystem changes
  - j. analyze and evaluate social and economic effects of environmental changes and crises resulting from phenomena such as floods, storms, and drought
- Strand VII: Production, Distribution, & Consumption
  - a. explain how the scarcity of productive resources (human, capital, technological, and natural) requires the development of economic systems to make decisions about how goods and services are to be produced and distributed
- Strand VIII: Science, Technology, & Society
  - b. make judgments about how science and technology have transformed the physical world and human society and our understanding of time, space, place, and human-environment interactions
- Strand IX: Global Connections
  - d. analyze the causes, consequences, and possible solutions to persistent, contemporary, and emerging global issues, such as health, security, resource allocation, economic development, and environmental quality
- Strand X: Civic Ideals & Practices
  - c. locate, access, analyze, organize, synthesize, evaluate, and apply information about selected public issues – identifying, describing, and evaluating multiple points of view

Glossary

Biocide—pesticide that kills microorganisms.

Biodiversity (or biological diversity)—the biological variety at all levels of organization including genetic variety within a species population, and species variety within an ecological community.[1]

Biological diversity—see biodiversity

Ecosystems—a community of plants, animals, and microorganisms that are linked by energy and nutrient flows and that interact with each other and with the physical environment. Rain forests, deserts, coral reefs, grasslands, and a rotting log are all examples of ecosystems.

Endemic—native to or found in only one area. Such species are especially vulnerable to extinction.[2]

Fungicide—pesticide that kills fungi, including blights, mildews, molds, and rusts.

Genetic diversity—the genetic variation present in a population or species. For example, the genetic diversity in the hundreds of varieties of potatoes can be seen by their differences in size, shape, color, taste, and rate of growth.

Herbicide—pesticide that kills weeds and other plants that grow where they are not wanted.

Insecticide—pesticide that kills insects and other arthropods.

Invasive species—a plant, animal, or other organism (such as a microbe) that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health.

Keystone species—A species in a community or ecosystem that many other species depend upon for continued survival and support. The great impact that keystone species have on other species is disproportionately large compared to its abundance. Examples include "ecosystem engineers" like the beaver and African elephant.

Native species—a plant or animal that occurs naturally in a certain area.

Nonnative species—a plant, animal, or other organism (such as a microbe) that has been introduced or moved by human activities to an area where it does not naturally occur. Non-native species are sometimes referred to as alien species.

Pesticide—any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest.

Population—the number of a particular species in a defined area.

Species—(1) a group of organisms that have a unique set of characteristics (like body shape and behavior) that distinguishes them from other organisms. If they reproduce, individuals within the same species can produce fertile offspring; (2) the basic unit of biological classification. Scientists refer to species using both their genus and species name. The house cat, for example, is called *Felis catus*.

Endnotes

1 Schmitz, Oswald J. *Ecology and Ecosystem Conservation.* Washington, DC: Island Press, 2007.

2 Miller, Jr., G. Tyler. *Living in the Environment*, 14th Ed. Pacific Grove, CA: Thomson Learning, Inc., 2005.