

# Biological Diversity

## The Eroding Foundation of Life

Almost unnoticed, the earth's living wealth is slipping away. As human populations expand and intensify their use of the land, species of wild things and their habitats disappear. With them go not only the beauty and variety of life created over millions of years but also environmental stability and untold potential for supplying human needs. Wild plants and animals are the very basis of our food, many of our medicines, and countless industrial products. As wildlife vanishes, our own life is impoverished, if not imperiled.

When scientists speak of biological diversity they simply mean variety of life: variety of species and their genetic variation, and variety of communities of plants and animals. Over billions of years, the earth has been enriched with an abundance of life forms. As different forms of life evolved, others died out—became extinct. Sometimes cataclysmic events like asteroid strikes, abrupt climate changes, or the advance of ice sheets caused mass extinctions. When they did, new species evolved that were adapted to the changed environment.

Today we are witnessing another extinction of unprecedented proportions, this one caused by humans. People are rapidly alter-

ing and destroying environments that have fostered a wondrous diversity of organisms. By early next century, at present rates of loss, a quarter of the world's existing plant and animal species (estimated at five million but possibly several times that number) may have vanished forever, many before they are identified and described. Some experts think that species are dying out at the rate of 100 a day. Over-harvesting or direct human exploitation is only partly to blame.

The main reason for this decline is *loss of habitat*, especially in the tropics, which support perhaps three-fourths of all life forms. Each year in those regions a forested area the size of Pennsylvania is cleared. The Amazon basin, for example, is the world's single richest region in species diversity. Deforestation threatens its million or more species and also its indigenous people and their traditional way of life, which from pre-Columbian times has been compatible with the sustainable and productive use of the forests. Things are little better in the industrialized countries, where every year thousands of square miles of natural habitat are converted to urban and agricultural uses and pollutants released into air and water degrade much of the living space that is left.

This destruction of nature is loaded with lasting consequences for our own species. If unchecked, the accelerating extinctions now going on seem likely to transform the workings of the biosphere, and in ways not beneficial to humans. The complex array of relationships among life forms will be disrupted. The loss of species is certain to divert us of resources and influence forever the course of evolution.

If there is to be a change for the better, it must begin with changed

thinking, and that must be based on understanding. Throughout history, enlightened people have seen the interconnectedness of all life. The ancient Greeks thought of the earth as a living organism. Buddhists teach that "each thing has its own intrinsic value, and is related to everything else in function and position." Tribal groups on all continents have lived this belief. The chief of the Kuna Indians in Panama recently expressed it this way: "The land is our mother, and all living things that live on her are brothers. We must live in a harmonious manner on her; because the extinction of one living thing is also the end of another." Affirming this age-old view, modern ecologists have shown the linkages in all communities of life.

National parks and other protected places are samples of the world's natural variety, often the last bastion of the earth's wild wealth. They are vital to our future well-being.

### The Stuff of Life: DNA and Genetic Diversity

Biological diversity rests ultimately on genetic diversity. This is because the survival of a species is intimately related to its ability to adapt, through variations in its genetic inheritance, to inevitable change in its environment.

Genetic diversity is the foundation of several levels of diversity. At the top are ecosystems, which are associations of plants and animals interacting with their physical environments. Forests of many kinds, deserts hot and cold, grasslands, tundra, lakes, streams—all are examples of ecosystems that support dis-

tinct groups of plants and animals in an intricate mosaic of life.

Ecosystems are composed of communities, species, populations within species, individual organisms, and genes of organisms. When biologists speak of a species, they mean a group of similar, related individuals that can breed and produce fertile offspring. A species may be further separated into local breeding populations that differ somewhat from each other in appearance or genetic structure. Individuals within populations to some degree also differ from each other in traits,

the way people differ in hair or eye color.

At the base of all this variation is the gene. It is the genes, acting within the constraints of environment, that control variation in living things. Genes are composed of the nucleic acid DNA, a complex chemical molecule that encodes all the information necessary for an organism to produce progeny that are essentially identical to it. Genes control the development of particular traits or characteristics. Bacteria have about 1,000 genes, a mouse about 100,000, some flowering plants about 400,000.

So great is the information stored within the genes of a single organism that when we lose a species it's equivalent to losing an entire library of books of which there are no other copies. Even if a species is not extinguished but only drastically reduced in numbers, there is still cause for concern, because it will have lost much of its natural genetic variation. Because of this loss, it will be less able to adapt to environmental change through the mechanism of natural selection. Those individuals with genetic traits suited to life in a changed environment tend to survive and pass

### Diversity and its Values

The loss of biological diversity is an accelerating, world-wide phenomenon. The aurochs, the wild ancestor of domestic cattle, disappeared in Europe in 1627. In central Asia, the tarpan, ancestor of the domestic horse, became extinct in the mid-1800s. As habitats in the Old World were increasingly altered, so wild species increasingly disappeared.

Here in North America our resources were once thought inexhaustible. Explorers described the American frontier as boundless, but in time prairies were tilled and forests leveled. Some species like the gray wolf were extirpated over most of their range and others like the passenger pigeon became extinct. Extinctions continue today, and obscure species like the noonday snail as well as spectacular ones like the grizzly bear are threatened.

Out of the relentless conversion of nature on this continent arose a movement for conservation. In 1872 the American people undertook a novel experiment. Yellowstone was set aside in "its natural condition" as the world's first national park. There are today more than 360 parks in the U.S. National Park System and more than 3,600 areas under similar protection around the globe. National parks and other public lands shelter well over half of the plant and animal species in North America. More than 80 countries have established several hundred biosphere reserves specifically to protect biological diversity.

The values of this diversity in parks are legion: the value of nature for its own sake, a source of wonder and enjoyment; the value of learning about the workings of nature in places largely free of human influence, for comparison with landscapes dominated by humans; the survival value of multitudes of wild species that flourish as natural systems helping regulate climate, air quality, and cycles of carbon, nitrogen, oxygen, mineral elements, and water—all fundamental to life on Earth. There is economic value in these same plants and animals. They are potential sources of food, medicine, and industrial products. Parks protect the species and their communities that underlie these values—serving if necessary as reservoirs of seed stock for restoring species lost elsewhere.

### Nature's Harvest

Nearly all the food in the supermarket was originally derived from wild sources. Of an estimated 80,000 types of plants known to be edible, only about 150 are extensively cultivated. A mere three crops—corn, wheat, and rice, all of wild origin—supply two-thirds of the world's total grain harvest.

Wild species are necessary to assure the continued productivity of our cultivated foods. The potato blight in Ireland during the 1840s led to the starvation of two million persons and prompted mass emigration to the United States. Eventually, the potato was cross-bred with several of its wild, disease-resistant relatives,

producing the many reliable varieties in use today.

Wild animal resources are also important. Commercial fishing, a \$75 billion-a-year industry worldwide, relies on natural systems, including coastal estuaries protected by many national seashores. On land, breeding domestic cattle with such genetically compatible wild species as the American bison may give us new breeds harder and more productive than current beef cattle.

Biological diversity is thus a form of insurance. If cultivated varieties of food fail because of events like disease or global warming, we can look for genetic infusions from the natural world. National parks and other preserves help insure that vital wild resources and their genetic information will continue to exist.

### New Medicines

Among other things, nature resembles a giant drug store. Almost one-quarter of all prescription drugs sold in the United States (an \$8 billion-a-year market) contain natural substances. Alkaloids, plant substances especially common in tropical plants, are used in cancer-fighting drugs, painkillers, blood-pressure boosters, anti-malarials, and muscle-relaxants. Probably the best known natural drug is penicillin, derived from *Penicillium* mold, a close relative of common bread molds. Aspirin also had a natural origin. Even when synthetic versions of drugs are developed, giving us substitutes for penicillin or aspirin, they are usually created by follow-

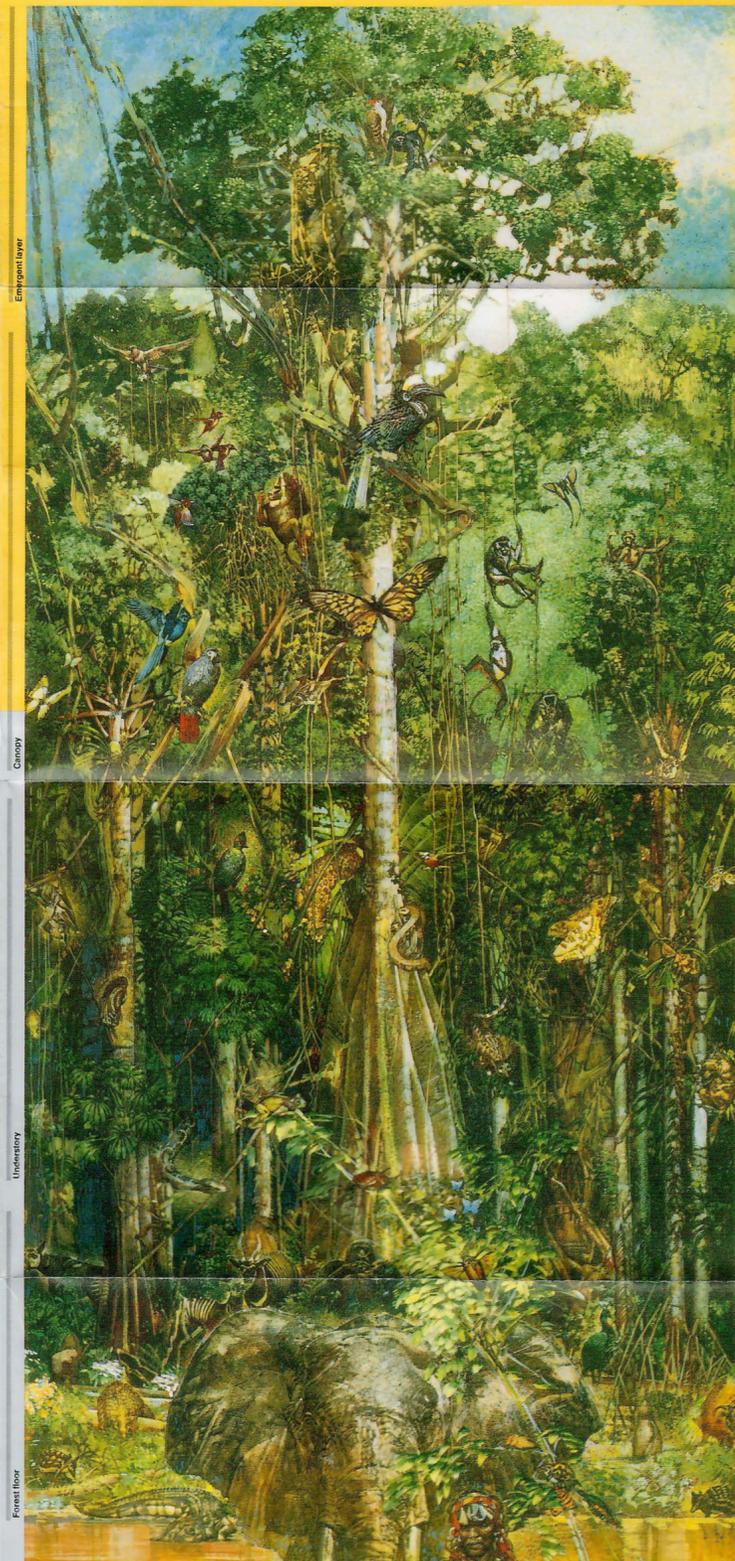
ing the "blueprints" of natural chemical compounds. Yet of Earth's hundreds of thousands of species of higher plants (estimates range between 250,000 and 750,000) only a relative handful have been exhaustively studied for their medicinal value. The world's flora surely holds many more cures for human ills.

Wild animals are also sources of many valuable medicinal properties. Fishliver oil, rich in vitamins A and D, is well known as a dietary supplement and for its uses as a soothing ointment for skin rashes. The horseshoe crab, *Limulus polyphemus*, found in waters off many of our national seashores, has a copper-based "blue" blood that is sensitive to some toxins. Extracts of this animal's blood are used to test vaccines and intravenous fluids for contamination and to diagnose human diseases.

### Benefits to Industry

When a space shuttle returns to earth, the first part to touch down is its tires made of natural rubber. Once just another plant in the jungle with a peculiar latex sap, the rubber tree became indispensable with the advent of the industrial age.

Rubber comes from trees native to the tropics of this hemisphere. Though petroleum-based synthetics have been developed, natural rubber is still essential in tires, especially aviation and truck tires, and vital in many other industrial products. In World Wars I and II scientists pressed the search for other natural sources of rubber. One likely



**Tropical rain forests teem with life.** At least half the world's species of plants and animals live there. These forests shelter a huge array of food, medicine, and industrial products and help to regulate Earth's basic processes. Yet recent studies suggest that they

are being destroyed at the rate of 50 million acres a year—a loss the world cannot afford. Illustrated here is an African rain forest. Its many layers support different species of plants and animals. Elephants roam the moist, shady forest floor. Some birds and mon-

keys inhabit the middle layers. The sunlit canopy, mostly hidden to human eyes, is home to other large groups, among them thousands of insects. Like living threads, vines span all the layers.

candidate was guayule, *Parthenium argentatum*, a shrub that grows in many places in the American Southwest, including Big Bend National Park. Guayule was planted and harvested successfully in the Southwest in the 1940s. Because the plant also yields hydrocarbons, researchers have an interest in guayule as an alternative source of petroleum. Examples abound of successful products derived from other plants. George Washington Carver, commemorated at George Washington Carver National Monument in Missouri, developed numerous products from plants during the first decades of the 20th century. Cloth from tomato vines, a plastic from soybeans, and cosmetics from peanut oil are samples of his ingenuity.

Life in a technical age is unimaginable without many other products that come from natural sources. Trees supply wood, paper, pulp, chemicals, and other products worth well over \$100 billion annually worldwide. Rayon, derived from wood chemicals, is important to cloth making. Ethanol, derived from fermenting corn, sorghum, or sugar cane, may well become an important source of fuel in a world short of petroleum. Industrial oils and waxes can be obtained from many plants and some animal species.

Nature is our security. By sustaining natural diversity through the establishment of national parks and other reserves, we protect potential genetic sources of economic wealth for the future.

# Biological Diversity

## Conserving the Earth's Wild Wealth

For eons, life on Earth slowly evolved through setbacks and resurgence to the amazing variety of recent times. But now that diversity is at risk. One species, our own, has risen to dominance at the expense of others. By its pervasive impacts, it threatens to unknit the planet's finely woven fabric of life.

This unknitting, if it continues, will harm human civilization too by foreclosing opportunities for spiritual, intellectual, social, and economic development. Addressing the loss of biological diversity will require the utmost in resourcefulness and flexibility. Much important work can be done only by governments, research institutions, and private organizations. It is vital, for example, that these groups promote systematic research on the world's biota to increase fundamental understanding and to give insight into the practicalities of conservation. All societies need creative planning to guide development into ways harmonious with the natural order.

This work can be achieved only if we as individuals change the way we value the natural world, for the issue of biological diversity is at heart ethical and personal. Knowledge and understanding should lead to changed values. As our understanding of the world's biological fabric grows, the ethics of our relationship to

the natural world will, in the words of biologist E.O. Wilson, "shift fundamentally so that everywhere, for reasons that have to do with the very fiber of the brain, the fauna and flora of a country will be thought part of the national heritage as important as its art [and] language."

If this is a reasonable hope, what can we do as a society and as individuals? In the past, our society decided that hunting, fishing, and timber harvesting should be regulated, and we established laws to accomplish this. More recently, we have taken steps to protect plants and animals headed toward extinction. These measures have helped greatly, but many of them focus on individual species and individual actions. We need now to think also in terms of entire ecosystems and of regional and national cooperation to conserve the biological diversity of our land. Individuals and organizations should view their actions within this framework.

Habitat loss is the crux of the problem. Many species have found their habitats wiped out or disrupted. Continuous forests have become patchworks of fields and woodlots. Prairie grasses have given way to corn and wheat, dense rain forest to open pasture. Highways, buildings, and parking lots cover additional thousands

of square miles every year. In the United States, little of our once vast primeval forest has escaped the axe and chainsaw. Some species, such as the robin and coyote, can adapt to such drastic change, but many others, like the grizzly bear and ivory-billed woodpecker, cannot. They survive, if at all, in the leftover pieces of their particular habitats.

In this country, the fate of biological diversity depends on private land owners and managers as much as it does on public officials and agencies. It is up to them—us—to include the needs of wild species in the use of land we tend. Homeowners can create miniature wildlife sanctuaries by maintaining natural habitats and minimizing the use of pesticides. Farmers can let nature have its way

along fence rows and in woodlots and odd corners. Timber companies can maintain old-growth forests. Cities and towns, using private means as well as public, can promote reforestation and pockets of nature. By changing our habits as consumers, each of us can help preserve nature at home and abroad. Even now tropical forests in Central America and the Amazon Basin are, for example, sacrificed for cattle and coca production—much of it for markets in North America.

Government can show the way to good stewardship of our land. The land in public trust ranges in size from small city parks to vast tracts of wilderness. Federal agencies alone account for one-third of the land in the United States, much of it natural. With wise administration of these lands, and regional and national cooperation among agencies based on overlapping goals, the future of biological diversity in this country will be brighter.

As we reshape the American landscape and requisition its riches, we would do well to heed the advice of conservationist Aldo Leopold. "To keep every cog and wheel," he said, "is the first precaution of intelligent tinkering."

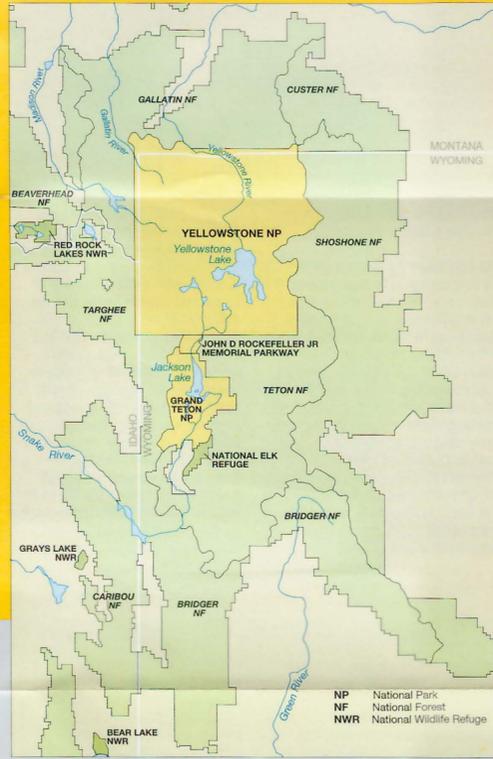
"In wildness is the preservation of the world." Henry David Thoreau



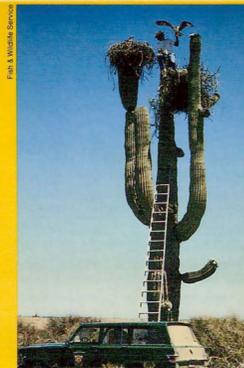
Caribou cross the Kobuk River near Kobuk Valley NP, Alaska. Vast herds follow ancient migratory routes through the park and adjacent federal lands.



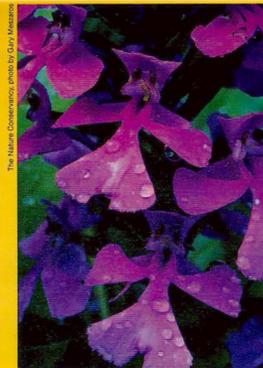
A controlled burn in Huron National Forest, Michigan, helps the U.S. Forest Service maintain young jack pine habitat for the endangered Kirtland's warbler.



The Yellowstone Region, 10-million acres in extent, is best understood as a biological unity. This large cluster of public lands sustains wide-ranging species such as grizzly bears and hundreds of smaller species.



Fish and Wildlife Service workers band nesting ospreys in Arizona.



Rare orchids at Blue Creek Swamp, Ohio, a Nature Conservancy property.

**Parks and Diversity**  
The land managers of America range from large public agencies to timber companies, ranchers, farmers, owners of private sanctuaries, even city dwellers who tend their shrubbery, yards, and gardens. They each have a role in maintaining biological diversity.

- 1) controlling exotic species that may compete with, prey on, or alter the gene pools of native species;
- 2) restoring lost or depleted native species (bighorn sheep in Yosemite, for example);
- 3) restoring natural habitats (tallgrass prairie in many midwestern parks);
- 4) finding out the habitat needs of endangered species (the manatee, panther, and snail kite at Everglades NP);
- 5) participating in regional management of migratory or far-ranging animals. An example involving Yellowstone and other parks is the Interagency Grizzly Bear Committee with federal, state, and Canadian members.

Of the public agencies, one of the most visible is the *National Park Service*, manager of 79 million acres of parkland. Its primary conservation mission in natural areas is to minimize human influences so that park ecosystems are governed by natural processes alone. Managers have learned that park boundaries are not barriers and that they must sometimes intervene to help nature follow its own course. Lightning fires, for example, are allowed to burn in certain areas if they do not threaten property or public safety, and some parks conduct controlled burning to restore conditions as they were before fires were suppressed. This practice helps maintain the natural variety of vegetation in its various stages of recovery from disturbance, along with the animals adapted to those stages. Another instance is predators. In former times, they were frequently removed from parks; now they are protected as natural elements of ecosystems and sometimes restored if missing.

When managers, with the help of research, understand how parks function as biological systems, they can take measures to maintain or restore native flora and fauna. These measures include:

Historic genetic resources are also conserved in parks. Rare orchard stocks are maintained at John Muir National Historic Site in California and several other parks. George Washington Birthplace National Monument in Virginia keeps globally rare Hog Island sheep and Ossabow hogs, once raised on sea islands along the Virginia and Georgia coasts.

Contrary to the popular phrase, parks are not places apart. They exist in regional settings. Park managers must work with their neighbors to lessen the impact of surrounding development. Equally critical are the long-term consequences of influences that are continental, if not global, in scope. The threats of acid rain and global warming are perhaps the best known. Parks can no longer be thought of as islands of nature. They share the fate of the biosphere.

**Stewards of the Land**  
By far the largest single landowner in the United States is the federal government.

The *Fish and Wildlife Service* manages 90 million acres of wildlife refuges and, among other duties, administers the Endangered Species Act, designed to restore species threatened with extinction.

The *Bureau of Land Management*, like other federal agencies, must by law identify any endangered species and take measures to safeguard them on land it administers. Though grazing, mining, and timbering are allowed on most of its 300-million-acre domain, the Bureau restricts use in habitats especially important to threatened species—the Snake River Birds of Prey Area in Idaho, for example.

The *Forest Service* is responsible for 191 million acres of national forests, habitat for a majority of the country's plant and vertebrate species. The agency's goal is to maintain the existing plant and animal diversity in national forests even as timber harvesting and other uses go on.

Other federal agencies protect significant amounts of wildlife habitat. The *Defense Department* is the custodian of 25 million acres. Hunting is allowed, but care is taken to protect rare or threatened species. The *National Oceanic and Atmospheric Administration* administers some 270,000 nautical square miles of marine and estuarine sanctuaries. Some 54 million acres of tribal

land held in trust by the federal government but managed by Native Americans provides varied habitat in many parts of the country.

In the private sphere, numerous organizations work to protect and sustain biological diversity. Two organizations notable for their effectiveness take different approaches to the task. *The Nature Conservancy*, widely known for rescuing many significant natural areas from development, conducts Natural Heritage Inventories to identify the locations of rare species so they can be protected. The *Center for Plant Conservation*, a consortium of 19 botanical gardens, is assembling a National Collection of Endangered Plants for research and restocking.

Yet no single organization, public or private, can alone assure biodiversity. Coordination is important. An example of this is the Yellowstone region (see map above), composed of two national parks, six national forests, four wildlife refuges, and numerous private holdings. Its 10 million acres make it one of the largest wildland tracts in the earth's temperate zone, large enough to support sizable populations of the wide-ranging grizzly bear, the rare trumpeter swan, and migratory elk. At least 25 different federal and state agencies have administrative responsibilities for this region, many of them overlapping. Remoteness once protected this land. Today its ecological health is dependent on thoughtful and well-coordinated management by many groups.

**World View**  
In many developing countries, conservation must be combined with help for the people. Until their basic needs are met, few people are likely to care about biodiversity. But wildlife has needs too. National

parks and similar protected areas are the only refuge for plants and animals that wane in human proximity. The golden tamarin (a small monkey) survives only in protected forests on Brazil's heavily developed southeastern coast. The

tiger depends on similar protection in densely populated India. Parks should therefore be part of regional economic development.

In 1971 UNESCO created another type of protected area, the biosphere reserve, to serve both conservation and development. These reserves have (1) core zones that remain natural to conserve diversity and (2) surrounding zones in which (often) traditional life continues and research is conducted on the sustainable use of forests, grassland, and other resources. Such zones often

protect the much-needed genetic diversity of crops and livestock used in traditional agriculture.

In 1992, there were 311 biosphere reserves in 81 countries, 47 in the United States alone. The goal is to establish at least one biosphere reserve in each of the world's land and coastal/marine regions.

Only 3 percent of the world's land area is now devoted to the preservation of nature for its own sake. Some countries have set aside as much as 38 percent of their territory; a few, nothing. For the United States the figure is 8 percent. Parks and reserves are vital but by themselves are not likely to be decisive in the quest to sustain diversity. If this quest is to succeed, much of it must also come about on lands used for many purposes.

**The World's Heritage**  
Some places transcend time and national boundaries and become the common inheritance of mankind. These places are now given international recognition as World Heritage Sites or Biosphere Reserves. Of the nearly 400 World Heritage Sites, over 100 are significant for their natural resources. The Galapagos Islands (Ecuador) and the Everglades (U.S.) are well known examples. Biosphere Reserves (numbering hundreds worldwide) are places in which traditional life, conservation, and research go hand-in-hand. A good example is the Southern Appalachian Biosphere Reserve, which links a number of parks and research sites.



World Heritage Sites and Biosphere Reserves are the shared inheritance of mankind. Red dots on the map above identify the 100 or so current natural World Heritage properties. Biosphere

Reserves, indicated by numbers for each continent, are representative samples of Earth's natural regions, places for learning how to live with nature. Their purposes are conservation of bio-

logical diversity and research and education on sustainable use of the land. Many other types of protected areas, not shown here, are also havens for the world's wildlife.