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Biodiversity: Connecting with the Tapestry of Life

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Biodiversity

Connecting with the Tapestry of Life

Smithsonian Institution Monitoring & Assessment of Biodiversity Program

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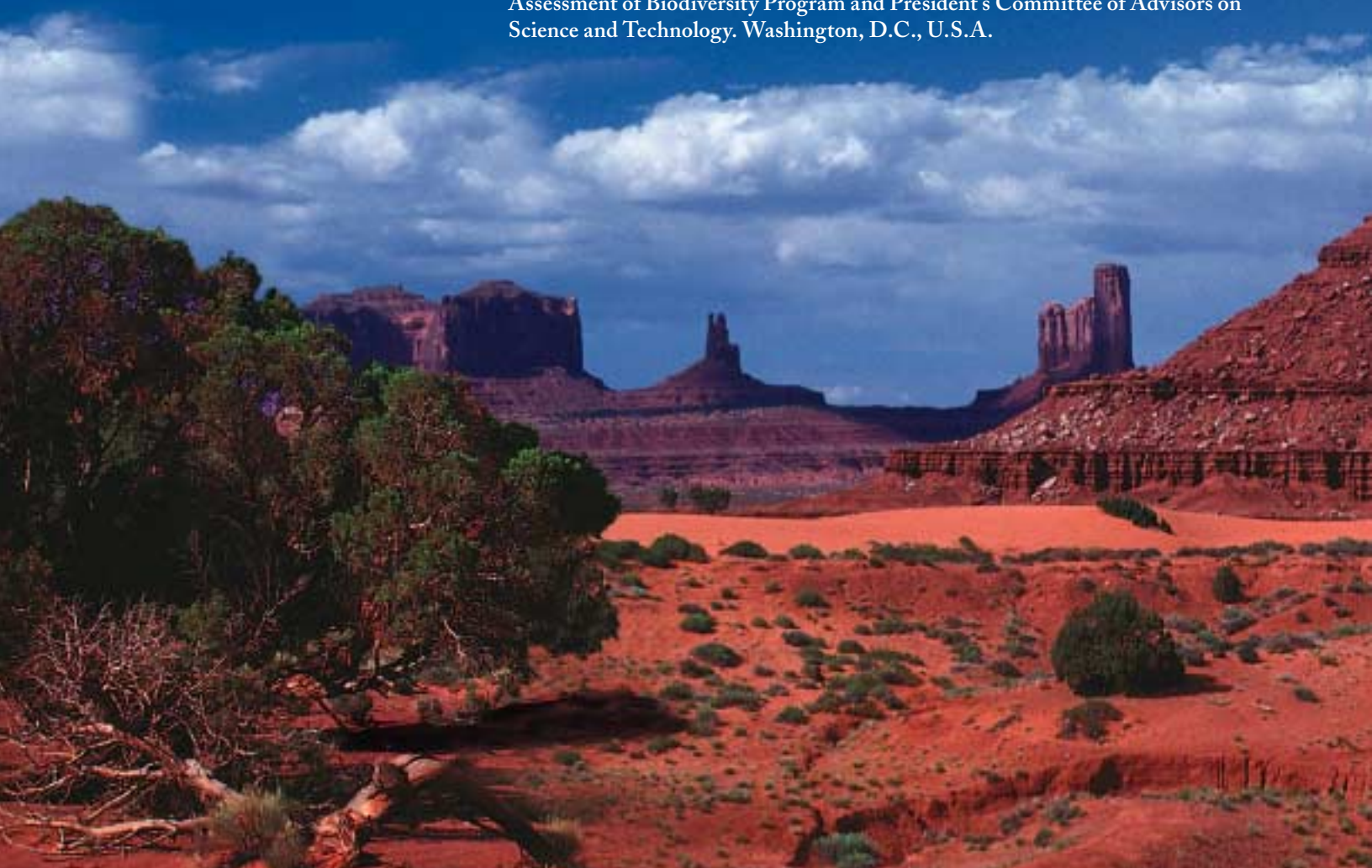

About this Booklet

Biodiversity is the extraordinary variety of life on Earth – from genes and species to ecosystems and the valuable functions they perform. E.O. Wilson, the noted biologist and author who coined the term "biodiversity," explains it as "the very stuff of life."

Species and the ecosystems in which they live are indelibly linked. Conversion or loss of ecosystems inevitably impairs the species that depend on them. As well, changes in the life cycle of one species could impact the life cycles of many other species (including humans), alter ecosystems and ecosystem functions, and contribute to local, regional and, ultimately, global changes.

Life as we know it will not be the same if our rich biodiversity heritage is dramatically altered. And the signs indicate that this is precisely what is happening. Biodiversity is threatened, and not because of catastrophic events such as the asteroid crash that scientists believe caused the extinction of the dinosaurs. The current threat to biodiversity, and thus to the tapestry of life, stems primarily from expanding human populations and increased human consumption of natural resources. Fortunately, together we can take steps to protect our rich biodiversity.

The Smithsonian Institution's Program on Monitoring and Assessment of Biodiversity, under the Conservation and Research Center of the National Zoological Park, and the President's Committee of Advisors on Science and Technology worked together to prepare this booklet. It explains what biodiversity is, why it is so important, why it is threatened, and what can be done to conserve this valuable resource. Read on to learn more about what we can all do to help.

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I. What is Biodiversity?

For at least 3.8 billion years, a complex web of life has been evolving here on Earth. Millions of species now inhabit land, freshwater and ocean ecosystems. All species, including human beings, are intricately linked.

Biodiversity – short for biological diversity – is the variety of all these living things and their interactions. Scientists often speak of three levels of diversity – species, genetic and ecosystem diversity. In effect, these levels cannot be separated. Each is important, interacting with and influencing the others. A change at one level can cause changes at the other levels.

Species Diversity

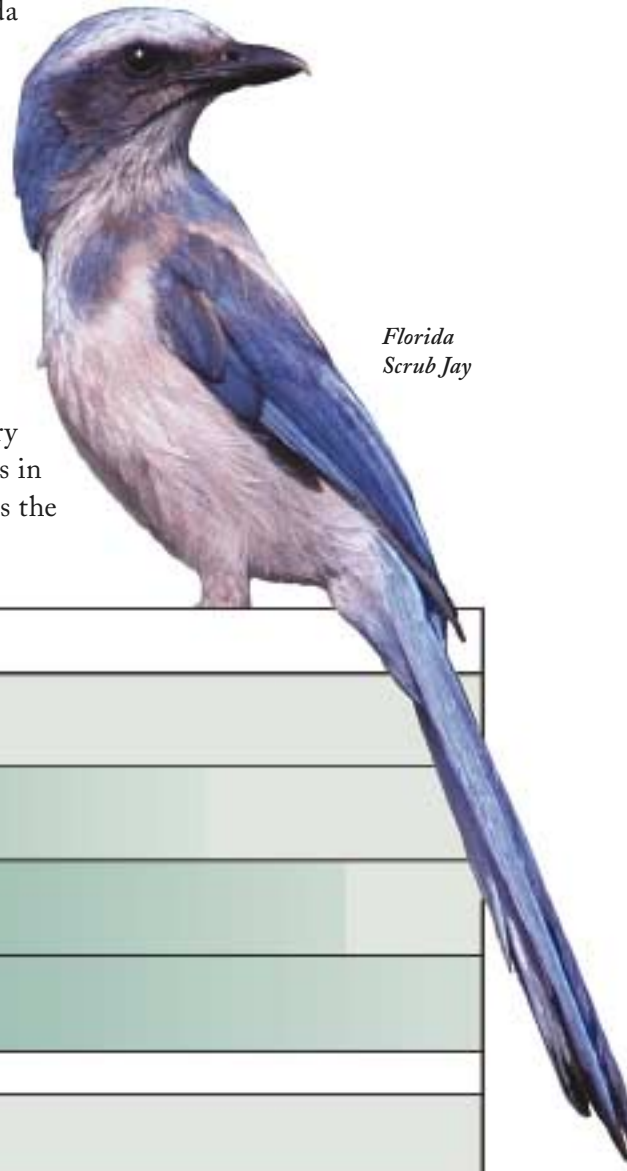
Species come in all shapes and sizes, from the tiny organisms that we can see only through a microscope to huge redwood trees. They include fungi, flowering plants, ants, beetles, butterflies, birds, and large animals such as elephants, whales and bears.

Each species is a group of organisms with unique characteristics. An individual of a species can reproduce successfully, creating viable offspring, only with another member of the same species.

We are still learning how many species exist and how they relate to each other and to their physical environment. Thus, we cannot predict the precise ripple effects that the loss of one species will have on others and on ecosystems. What we do know is that certain species, called keystone species, play critical roles in the ecosystems they inhabit because they affect the abundance and health of many other species. Examples of keystone species include brown algae, commonly known as kelp, in Pacific coastal ecosystems, fruit-eating bats in southwestern deserts, and corals in tropical coastal waters. Their loss may well endanger other species.

Some species such as whales, seagulls and sea grass are naturally common around the world. A number of species such as eucalyptus are common worldwide because humans introduced them in places where they did not occur naturally. Other species, called endemic species, are found exclusively in a particular area, indicating the existence of unique habitats in limited geographic areas. The Florida scrub jay, for example, is found in shrubby scrub vegetation only in the state of Florida. The Owens pupfish is found only in Owens Valley, California. If these habitats are damaged or destroyed, it almost certainly means the end of the endemic species they shelter.

Scientists estimate that there are millions of species on Earth — perhaps 10 million or more — that have not yet been identified. Many of the undiscovered species live in tropical and ocean environments that have not been thoroughly explored. Approximately 204,000 species have been identified in the United States, which is 8 percent of the world's total known species. Many species of insects, fungi and other microscopic organisms in this country remain unidentified. Scientists estimate that the total number of species in the United States is between 400,000 and 600,000 – two to three times the number now known.



Florida Scrub Jay

Known Species


12,000 species of amphibians and reptiles


4,000 species of bacteria


4,500 species of mammals


5,000 species of viruses


10,000 species of birds


22,000 species of fish


70,000 species of fungi


270,000 species of plants


400,000 species of invertebrates (excluding insects)


960,000 species of insects, approximately 600,000 of which are beetles

Genetic Diversity

Biodiversity is much more than the variety of species. It also includes the genes that every individual inherits from its parents and passes on to the next generation. Genetic diversity is everywhere, from the variety of songs and feather colors of the birds in your backyard to the many colors, tastes and textures of apples and other foods in your grocery store. Genetic diversity exists within your own family. For instance, you and your siblings might have different eye and hair colors, body shapes and heights.

Genetic variation is extremely important to the survival of species. As experienced gardeners know, certain seeds from the same packet produce plants that grow taller or have more leaves than others, or that mature faster or are more resistant to diseases and insect attacks. Genetic variability, responsible for these different traits, interacts with local environmental conditions to determine the extent to which populations can adapt to environmental changes and survive exposure to new diseases. Isolated populations such as those on ocean islands or in small patches of habitat cut off from the surrounding environment tend to have less genetic variation than populations in large, intact ecosystems. Therefore, those isolated populations are more susceptible to extinction.

Where does most of the world's biodiversity exist?

Biodiversity is everywhere. In deserts, oceans, freshwater bodies, tropical rainforests, temperate zone forests and your backyard. The rainforests of Central and South America, equatorial Africa, and Southeast Asia may house at least half of the world's species. A large number of plant and animal species call coral reefs – the "rainforests of the seas" – their home. Lakes, estuaries, the deep ocean floor and the soil beneath your feet are also rich in biodiversity, while extreme arctic climates and torrid deserts contain some of the most unusual living organisms.

Ecosystem Diversity

Genes determine the traits of the individuals that form populations of a species. Populations and the non-living environmental components – such as water or minerals – surrounding them interact dynamically to form an ecosystem. Ecosystem interactions include predators consuming prey, pollinators selecting flowers and species responding to physical processes, such as heavy rainfall. Plant and animal communities make up the many kinds of ecosystems we are familiar with today – from estuaries, ponds, fjords, marshes, coral reefs and other aquatic ecosystems to savannas, prairies, forests, deserts, mountaintops and other terrestrial ecosystems, including neighborhood parks, school grounds and backyards.

Species are not evenly distributed around the globe. Some ecosystems such as tropical forests and coral reefs are very complex and host a large number of species. Other ecosystems such as deserts and arctic regions have less biodiversity but are equally important.

Photos at right from top to bottom: a Florida sand dune ripe with vegetation; national forest in the Smoky Mountains of North Carolina; summer flowers in a mountain meadow near Homer, Alaska; one of the Florida keys - a diverse coastal ecosystem; red rock with arid ecosystem vegetation in Monument Valley on the Arizona-Utah border.

Background: the Florida coast at sunset.

II. The Importance of Biodiversity

Biodiversity produces goods and services for the most fundamental of our needs – clear air, fresh water, food, medicines and shelter. It also provides people with recreational, psychological, emotional and spiritual enjoyment. Some people believe we should protect and restore biodiversity because of its benefits to us. Others believe that we have a moral responsibility to protect biodiversity simply because all organisms have value, whether or not we understand their benefits to us.

Direct Products

Food

Simply stated, our food comes directly or indirectly from plants. More than 90 percent of the calories consumed by people worldwide come from 80 plant species. Fruits, nuts, mushrooms, honey, spices and other foods that humans and wildlife consume originate from natural ecosystems. In the United States, most food is the result of large-scale intensive agricultural production of a few hundred crops and animals that originated from varieties found in nature.

Medicines

An estimated 4.5 billion people (about 80 percent of the world's population) still use plants as their primary source of medicine. The use of most of these medicines is based on ancestral knowledge. Close to 30 percent of all pharmaceuticals on the market today were developed from plants and animals. Antibiotics such as penicillin are extracted from fungi and from such unlikely sources as the African clawed frog's skin. The saliva of the vampire bat is used in treatment to unclog arteries. Wild yams have chemicals with anti-inflammatory properties. Ovarian and breast cancer treatments have been developed from the bark of the Pacific yew tree found in the northwestern United States.

Many plant species contain chemicals that are used to make painkillers, blood pressure boosters, anti-malarial drugs and anti-leukemia drugs. Most plants have yet to be tested for their potential medicinal properties. The oceans are also a rich source of both biological and chemical diversity. Natural marine products have potential as pharmaceuticals, nutritional supplements, agricultural chemicals, and biomedical research probes that give us valuable insight into understanding and treating human diseases. As species in oceans, tropical rainforests, and other habitats go extinct, we may be losing valuable medicines for as yet untreatable diseases.

Fuel, Timber, Fiber and Other Resources

Most houses, furniture and even many clothes are made from natural products, including wood, oils, resins, waxes, gums and fibers. The cocoons of silk worms are the basis of the valuable, centuries-old Asian silk-making industry. For centuries, Brazilians have extracted rubber from trees, and many people rely heavily on wood and other plant parts to build homes.

Far left: A totem of a beaver from a Native American group in Alaska.

Left: Trees are tapped to extract rubber and other gums used in products such as tires, elastics and chewing gum.

Right: Cocoons from the silk worm are woven into thread.

Inspiration and Cultural Attributes

The ethical and religious beliefs of cultures around the world include respect for and protection of nature. Some species such as the bald eagle are part of cultural heritages, while others – for example, turtles and bison – are integral to religious and spiritual beliefs. Species inspire songs, stories, dances, poetry, myths, crafts, regional cuisines, decorations, rituals, festivals, holidays and even names for sports teams.

Our connection with biodiversity is also evident through common activities such as gardening, keeping pets and watching birds. And for many of us, nature is an unsurpassed source of relaxation, wonderment, rejuvenation, beauty and peace. Research indicates that mental health and social conditions may be affected by loss of contact with the natural environment and its life forms.

Ecosystem Services

Biodiversity provides us with life-sustaining services. As stated below, these ecosystem services have a much higher value than most people realize.

Pollination

For every third bite you take, you can thank a pollinator. Many flowering plants rely on animals such as bees, butterflies, moths, wasps, beetles, birds, and bats for pollination to produce fruit. Thirty percent of our food crops, including almonds, apples, blueberries, cherries, cranberries and chocolate, rely on the free services of pollinators. Feed crops like alfalfa and hay for domesticated animals also depend on pollinators, and many wild plants such as fig trees that provide food and shelter for animals depend on pollinators. But pollinators, including the managed honeybee colonies used extensively in U.S. agriculture, are threatened. Increasingly fragmented and degraded habitat, pesticides, and the introduction of diseases and non-native species are causing some pollinator populations to decline. Imagine farmers having to hand-pollinate their crops if we lose natural pollinators.

Air and Water Purification

Biodiversity maintains the air we breathe and the water we drink. Forests purify our air and our water by taking in carbon dioxide, regulating water vapor, releasing oxygen, and cycling nutrients. Through photosynthesis, trees and other plants give off oxygen that helps maintain a breathable atmosphere. As a result of these processes, plants play a crucial role in maintaining the planet's water cycle. Wetlands and the vast array of bacteria and other microscopic species they house also act as water filters; wetland vegetation releases oxygen and absorbs carbon dioxide.

Climate Modification

By giving off moisture through their leaves and providing shade, plants help keep us and other animals cool. Forests are especially good climate modifiers. As trees and other plants in forests release oxygen and take up carbon dioxide (CO_2) – the most prevalent greenhouse gas – the forests act to store carbon and help reduce global warming. So do oceans as they interact with the atmosphere. Algae living in the ocean take up carbon dioxide, and ocean currents and winds help control the world's climate.

Drought and Flood Control

Plant communities, especially forests and wetlands, help control floods. The root systems of plants hold soils in place, preventing erosion and mudslides. Plants also hold moisture in soils and thereby help reduce the effects of drought. Lands that have been deforested and cleared, on the other hand, have less ability to hold water. These natural drought and flood control services are particularly important to people living along rivers and coastlines and for people in arid regions.

Cycling of Nutrients

Pick up just a tiny bit of soil and you will discover a whole new world. Researchers have found that one pinch of soil can contain more than 30,000 protozoa, 50,000 algae, 400,000 fungi and billions of individual bacteria; larger organisms like worms, insects and mites also live in the soil. These organisms break down dead plants and animals and recycle the nutrients into organic materials that enrich the soil.

Habitat

Natural ecosystems provide habitat for the world's species. Forests, coral reefs and deep ocean bottoms house many species. Wetlands, through their mix of aquatic and terrestrial environments, nourish and shelter thousands of bird, fish and other animal species. Estuaries, where the currents and tides of salt water and fresh water meet, are the world's nurseries for many of the aquatic species we consume, including fish and shellfish such as clams and crabs. Lakes and rivers, for example, constitute only 0.01 percent of the planet's water, but they contain a quarter of all known species. Even open spaces in cities and towns can house significant biodiversity.

Young trees grow out of a fallen, decomposing old growth tree in a Pacific Northwest forest – the ultimate cycling of nutrients. Inset: Coral reefs provide habitat for a rich diversity of marine species.

Economic Value

Biodiversity serves as an income-generating activity for countries around the world. Many people visit forests, beaches, mountains, grasslands, lakes, ponds, estuaries and streams for extended vacations or shorter periods of relaxation. More than 130 million people visit U.S. national parks each year, and millions of dollars are spent annually on nature activities such as hiking, camping, fishing, hunting, whale watching and wildlife photography. In the United States alone, people spent $16 billion in 1991 on sport fishing – far more than the $8.2 billion produced that year from global commercial harvesting of freshwater fish for consumption. More people visit zoos and aquariums in the United States and Canada than attend all professional sporting events in the two countries combined. Around the world the number of ecotourists, people traveling to enjoy nature and various cultures, is increasing.

Putting a Price on Ecosystem Services

Ecosystem services are priceless since no life, including our own, would exist without them. But if we try to estimate the value of ecosystem services worldwide, they would be approximately $33 trillion a year – almost twice the estimated $18 trillion value of all goods and services produced by people. For example, currently the Catskill watershed provides New York City's water. To replace it would cost $6-8 billion and the annual operation would cost around $300 million – a high price for a resource provided free by healthy ecosystems. Imagine having to replace the ecosystem products and services listed in this chart.

ECOSYSTEM PRODUCTS AND SERVICES	ESTIMATED VALUE IN U.S. DOLLARS
Soil bacterial services such as converting nitrogen into a usable form for crops, pastures, forests and natural vegetation	$33 billion per year
Insect pollination of over 40 U.S. commercial crops	$30 billion per year
Economic activity generated by the 350 million visitors to U.S. national parks, wildlife refuges and other Department of the Interior and Department of Agriculture public lands through expenditures on fishing, hiking, hunting, whale watching and wildlife photography	More than 400,000 jobs and $28 billion per year
1990 sales in the U.S. of prescription drugs containing ingredients taken or derived from wild plants	More than $15 billion
Genetic traits from wild crop varieties introduced into domestic agricultural crops in the U.S.	$8 billion per year
Commercial and sport fishing revenue lost because of destruction of U.S. estuaries between 1954 and 1978	More than $200 million
Annual ocean fish catch worth to the U.S. economy	$2.5 billion
Value of flood control services provided by marshlands near the Charles River in Boston, Massachusetts	$72,000 per acre of marshland
Products from natural and managed forests including timber, fuelwood, game, fruits, nuts, mushrooms, honey, etc. contributing to U.S. economy	$3 billion - $8 billion per year

III. Status and Trends in Biodiversity

Even without human actions, a few species naturally become extinct over time. However, during certain periods of geological time, great numbers have been lost relatively quickly – on the scale of thousands of years. Scientists have documented five mass extinctions since the emergence of life on this planet some 3.8 billion years ago. It is thought that each of these episodes, during which a large fraction of all species were lost, was caused by a catastrophic natural event. For example, the disappearance of two-thirds of all species living on land during the time of the dinosaurs was probably the result of a large asteroid crashing into Earth about 65 million years ago. Because today's extinction rates are exceptionally high, many scientists consider this the sixth extinction episode.

Current Status and Rates of Loss of Biodiversity

Based on fossil records, paleontologists estimate that 1 to 10 species go extinct as part of natural processes every year. Today's extinction rate is several hundred times greater than the natural rate and higher than any other on record. Many scientists think that we are now in the midst of an unnatural mass extinction. This time, it is caused primarily by our growing population and the demands that we place on natural resources. If this high extinction rate continues, it will grow to as much as 10,000 times higher than the natural rate, and result in the extinction of as many as two out of every three terrestrial species by the end of the century.

A growing human population, increased human consumption, and the growth of technology are placing tremendous stress on Earth's natural systems. Over the past 50 years alone, world population grew from 2.5 billion to 6 billion people, and global energy use tripled. More than 6 billion people now inhabit the planet, and the United Nations predicts that by the year 2050 there may be about 9 billion. More people require more land, water, food, energy and minerals. As our consumption of Earth's resources grows, we are likely to see a corresponding loss of biodiversity around the world. If all people worldwide enjoyed the standard of living of the United States, it would require four more planet Earths to support today's human population.

Although developed countries such as the United States, Canada, Japan, Australia and most European nations have only 20 percent of the world's human population, they consume 80 percent of global energy use and 85 percent of the world's economy - a disproportionate share of natural resources. These developed countries also produce far more waste than developing nations, such as China, India and many Latin American and African nations. For this reason, the choices we make are important for the conservation of biodiversity.

Fossil imprint of a prehistoric species

Documented Island Extinctions Caused by Human Activities

Crete, Sicily, Malta, and other Mediterranean Sea islands	Large mammal species including land tortoises, dwarf elephants and hippopotamuses
West Indies	Endemic sloths, monkeys, rodents, snakes and others
Madagascar	24 species of mammals, birds and tortoises
Hawaii	An estimated two-thirds of all native vertebrates and more than 90 percent of all land bird species
New Zealand	Frogs, lizards, and an estimated 30 bird species including 11 endemic species

Factors Leading to Biodiversity Loss

A recent gathering of biodiversity experts concluded that the leading causes of biodiversity loss during the coming century will include land-use changes, changing levels of atmospheric carbon dioxide, changing climate, invasive species and nitrogen deposition (air pollution). Most of these stresses will cause degradation and loss of habitat, rather than direct harm to species.

Habitat Loss

Most species need undisturbed habitat – unpolluted living space to find food and nutrients, water, shelter and mates. But people are altering habitats all over the world. We log forests, fill in wetlands, plow prairies for farms, graze livestock in once-undisturbed grasslands, mine, and build new settlements. We build housing developments, roads, shopping malls, office buildings, golf courses and vacation resorts. All of these actions change landscapes, natural water flows, and the species composition of an area. Aquatic habitats are destroyed as we dam rivers and trawl the ocean beds.

In many situations, habitat loss is the result of multiple stresses that operate together. For example, frogs, lizards and birds in Costa Rica's high-elevation cloud forests are disappearing as their habitat declines. Climate and land-use changes are reducing the amount of moisture-laden winds needed to form the cloudbanks upon which the habitat depends.

Where habitats are not completely destroyed, they are fragmented into smaller patches, creating islands of habitat in a sea of development. Fragmentation exposes species to more light, wind and temperature effects than are natural, thus affecting the species' survival as food and water sources are lost and few mates remain. In fragmented landscapes, many species soon become isolated from others of their own kind, resulting in inbreeding, loss of genetic diversity, and local extinction.

When natural habitat is fragmented – by clearcutting forests, damming rivers, clearing land for development or farming, or filling in wetlands – the land may become an incomplete tapestry, like a puzzle with missing pieces.

Invasive Species

Purposely or accidentally, people often bring non-native species into new areas where the species have few or no natural predators to keep their populations in check. These invasive species – also called alien, introduced or exotic species – are considered the second most important cause of biodiversity loss, after habitat destruction. For example, invasive species have played a major role in the listing of 35 to 46 percent of all species currently considered endangered or threatened in the United States.

Invasive species also wreak economic and environmental havoc. Invasive plants, mammals, birds, amphibians, reptiles, fish, arthropods and mollusks cost the United States an estimated $137 billion annually. In the Great Lakes and other North American freshwater systems, the invasive zebra mussel has caused hundreds of millions of dollars in damage to water equipment, power plants and other facilities. The full ecological impacts of the zebra mussel are still unknown, but native freshwater ecosystems that this creature invaded have undergone significant changes, including the loss of many populations of native mussel species. Invasive species can also alter fire cycles, nutrient cycling, and the hydrology and energy budgets in native ecosystems.

Fire ants have a major impact on the U.S. economy

Examples of Impacts of Invasive Species

- Invasive plants cover an estimated 100 million acres in the United States and are spreading annually across three million additional acres, an area twice the size of Delaware.
- U.S. farmers spend billions of dollars every year on pesticides, which are used in part to eliminate weeds – many of them non-native invasive species.
- The invasive sea lamprey collapsed lake trout and other native Great Lakes fisheries. The United States and Canada spend $13 million per year attempting to control this pest.
- Invasive brown tree snakes have bitten at least 200 people, caused 1200 electrical outages and driven most ground-dwelling native birds to extinction on Guam.

Overuse of Resources

People use some plant and animal species at a greater rate than the species can replace themselves, which can lead to extinction. Nine of the world's major ocean fisheries are declining because of too much fishing as well as water pollution and habitat destruction. Popular commercial species such as the southern bluefin tuna, the Atlantic halibut and the Pacific and Atlantic salmon are now threatened. Current logging rates threaten to eliminate mahogany and other tree species that take many years to grow and mature.

The $10 billion-a-year global market in wildlife – for pets, folk medicines, gourmet foods, decorative objects and other uses – threatens elephants and rhinos, sea horses and colorful corals, tropical plants and birds, and bears, pandas and tigers. Each year, consumers in the United States alone buy as many as 12,000 primates, 2.5 million orchids, 200,000 live birds, 2 million reptiles, 250 million tropical fish and a large number of wildlife products. Nearly one-fourth of the trade in wildlife relies on poaching.

National parks, like Canyonlands in Utah, are among our most pristine areas, serving as laboratories for research on the effects of pollution, global climate change and other impacts on biodiversity.

Pollution

The more we consume, the more we generate waste and pollution, which threatens biodiversity and our own health. Pollution comes in many forms – oil spills, acid precipitation, toxic chemicals in fertilizers and pesticides, and urban and suburban sewage runoff, to name a few. Pollution may kill organisms outright or it may weaken them by interfering with vital processes such as mobility and reproduction. Pesticides harm wild insect pollinators, including managed honeybee populations, which can in turn reduce crop yields. Runoff seeping into rivers, lakes and coastal environments can produce negative impacts on entire aquatic ecosystems. In the United States alone, pesticides kill an estimated 75 million birds and billions of non-target insects on croplands every year.

Some 140,000 people become sick because of pesticides and pesticide runoff each year. Several pesticides banned in the United States are still exported to developing countries. Of particular concern are chemicals called endocrine disrupters such as DDT, DDE and PCBs. These substances mimic or interfere with normal hormones in living organisms. Reproductive abnormalities have been found in alligators, terns, salmon and gulls exposed to high levels of chemicals from pesticides and animal hormones in their environment.

Global Climate Change

Substantial evidence demonstrates that people are contributing to measurable changes in the global climate, threatening life as we know it. By burning fossil fuels such as oil, natural gas and coal and by burning trees to clear forests, we have dramatically increased the amount of CO_2 in the atmosphere. While scientists do not know the exact effects of increased CO_2, they predict that it will lead to higher overall global temperatures, increasing sea levels, and changes in climate patterns.

The changed atmospheric conditions that result from global warming could create greater numbers of intense storms and prolonged droughts. The warming may lead certain species to expand their ranges, including mosquitoes that carry malaria and encephalitis among other diseases. On the other hand, the expected speed of climate changes coupled with direct loss of natural habitat may prevent some species from adapting quickly enough. They are likely to become extinct, locally or more broadly, and their roles in natural systems will be lost forever.

Many ecosystems are highly vulnerable to the projected rate and magnitude of climate change. Corals are "bleaching" (losing their necessary symbiotic algae) throughout the world because of increased water temperatures, and many are not recovering. A few ecosystems such as alpine meadows in the Rocky Mountains and some barrier islands could potentially disappear in certain areas. Others such as forests in the Southeast are likely to experience major shifts in the makeup of their species or become fragmented into pieces of grasslands, woodlands and forested areas. The goods and services lost as ecosystems are fragmented or disappear, including changes to and loss of biodiversity, are likely to be very costly or impossible to replace.

Consequences and Implications of Biodiversity Loss

The continued loss of biodiversity will greatly impact human society as well as ecosystems and their valuable services. It is difficult to quantify these impacts. But looking at all the products and services biodiversity provides – and the difficulty of their replacement – gives us an idea of the magnitude of the consequences we face if we do not conserve the biodiversity that remains.

Biodiversity loss will severely limit our quality of life, not to mention the potential to feed, clothe and shelter future generations. It is not possible to account accurately for the costs of losing undiscovered species that may be the source of new varieties of foods, medicines, fuels, timber and other resources. Furthermore, the loss of ecosystem services such as pollination, clean air and water, climate regulation, drought and flood control, and nutrient recycling will impact all species of plants and animals, not just humans. Not even factored into the equation is the cost of unknown ripple effects that a change in one species or ecosystem may have on other ecosystems and on the entire planet.

Loss of biodiversity can have indirect and unforeseen effects on jobs and the economy. In the Pacific Northwest, the loss of salmon populations due to habitat degradation has virtually eliminated one of the largest industries in the region and resulted in significant impacts on the regional economy and culture. There is no way, of course, to estimate losses of psychological, emotional and spiritual well-being that will result from ruined forests, beaches, lakes and other places people rely on for rejuvenation.

The Status of North American Biodiversity

North America contains a variety of species and ecosystems, including temperate rainforests, grasslands, wetlands, deserts and more. Species in the United States include grizzly bears, spotted owls, ghost-faced bats, horned puffins and redwood trees, as only a few examples.

Like the tropics, North America's storehouse of biodiversity is being threatened. As of May 2000, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service combined had listed 1,231 species (496 animal species and 735 plant species) as endangered or threatened in the United States. Hundreds of other species are being considered as possible additions to the list. According to The Nature Conservancy, one-third of all U.S. plant and animal species are in need of protection. Many freshwater fishes and wetland species such as mussels, crayfish and amphibians are particularly vulnerable. Nearly 500 species in the United States may already be extinct.

Canada's endangered species list included 353 species as of May 2000. Among them are the wolverine, killer whale, eastern barn owl, western rattlesnake, tailed frog, white-throated swift, peregrine falcon and whooping crane. Many of Canada's ecosystems are also in danger. According to the Canadian Nature Federation, 240 acres of wildlife habitat are converted or fragmented every hour in Canada, and habitat destruction threatens more than 80 percent of Canada's endangered species with extinction.

In the United States, we have lost hundreds of species to extinction and thousands more are endangered or threatened. Here are some commonly known species:

Extinct Species

Labrador Duck
Passenger Pigeon
Carolina Parakeet
Great Auk
Silver Trout
Harelip Sucker Fish
Palo Alto Thistle
Xerces Blue Butterfly
Wabash Riffleshell
West Indian Monk Seal

Endangered Species

California Condor
Florida Panther
Gray Wolf
West Indian Manatee
Black-footed Ferret
Golden-cheeked Warbler
Indiana Bat
Stellar Sea Lion
Atlantic and Chinook Salmon
Green Sea Turtle

Mexico's rich biodiversity is also being lost. Home to nearly 10 percent of the world's terrestrial species, Mexico has a high number of endemic species, the richest diversity of reptiles and cacti, and the second richest diversity of mammals in the world. But almost half of Mexico's 25 million hectares of tropical dry and humid forests have been cleared for agriculture and grazing, leaving only 10 percent in stable condition. More than 50 percent of Mexico is dry scrubland or desert, and overgrazing and human-caused fires have degraded much of this land.

Consider the following facts compiled by the World Wildlife Fund:

North American Ecosystem	PERCENTAGE OF ECOSYSTEM LOST	
Original North American tallgrass prairie – More than	*99% transformed*	
Original primary forest in the 48 contiguous United States – More than	*95% lost*	
Midwest oak savanna – More than	*98% altered*	
Old growth forest in the Pacific Northwest – About	*90% cleared*	
Wild or scenic rivers in the United States – Between	*90-98% degraded*	
Coastal sage scrub in the United States – Between	*70-90% disturbed*	
Original wetlands in the United States – More than	*50% drained and filled*	

IV. Actions to Conserve Biodiversity

Protecting biodiversity over the long term involves balancing the immediate needs, rights and desires of individuals and communities with protection of species and ecosystems. People around the world require food, water, shelter, clothes and medicine. These needs are real and immediate, and they must be considered along with biodiversity conservation choices.

The complexity of factors contributing to global biodiversity loss, coupled with human values and needs, means that there is no one perfect strategy to combat and reduce biodiversity loss. Scientists, conservationists, economists, government officials, business and community leaders and citizens debate the pros and cons of various approaches. No matter what the course of action, however, credible science should underlie every plan and decision.

Research and Sound Science

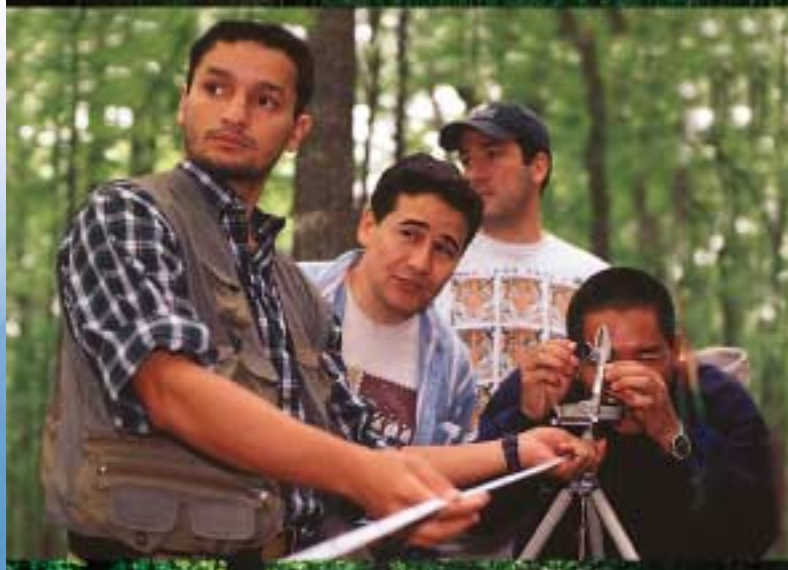
Slowing biodiversity loss requires accurate, reliable, scientific information from natural and social sciences. Research can reduce uncertainties about why species decline and can lower the costs of carrying out appropriate policies to protect biodiversity and the services it provides. Sound science allows us to devise suitable environmental and social policies and to develop management strategies that experts can apply to complex systems.

Federal agencies such as the National Science Foundation, the U.S. Forest Service and the U.S. Geological Survey are actively pursuing basic and applied research in biodiversity, as are universities and private foundations. And recently, public and private entities began a cooperative venture to make information on biodiversity more accessible through the National Biological Information Infrastructure, and at the international level through the Global Biodiversity Information Facility.

A number of programs around the world focus on biodiversity field research. Following carefully tested protocols, biodiversity researchers enter an area to make an initial assessment of what is there. They record all plants and animals and note their size, condition, location and numbers. This information, the vital signs of life, is carefully entered in daily logs and statistical sheets. Specialists in vegetation, aquatic systems, insects, amphibians, reptiles, birds, mammals and other biological groups, as well as data analysts and statisticians, make up the research teams.

On their next visits to the area, the researchers again record what is there to compare against the baseline information gathered during the initial field assessment. Continuous monitoring of vital signs will indicate if populations are shifting. The researchers may choose one or more "indicator" species for long-term monitoring. If populations of the indicator species shift, it is likely that changes in the natural system have occurred. The next step is to determine why and how those changes came about and the extent to which they may negatively impact the natural system.

This research is critical to reliably establish the specific causes of the measured changes and may require considerable time and cost. It may take the form of monitoring hypothesized changes in climate, distribution of land uses, loss of food sources, increase of atmospheric contaminants, or a myriad of other factors. Most declines in populations are caused by multiple stressors operating together. Indeed, the biological populations may not be particularly vulnerable to any one of the factors alone. But unless researchers document the causes of decline and the interrelationship of those causes, any actions taken to reduce harmful impacts will likely be ineffective in restoring population health.



Approaches for Conserving Biodiversity

Increase Knowledge

Studying biodiversity helps us understand how nature works and our role in it. We need to know more about how ecosystems work and about their fundamental parts – species, their genetic richness, and complex habitats. Through standardized methods to assess and monitor biodiversity and the stresses that cause it to change, scientists can detect changes in species over time and determine why those changes occurred.

As a result, people will have the knowledge to make the best decisions regarding the challenges associated with resource conservation and development. We should be better positioned to meet our current needs for food, shelter and energy without compromising the ability of our children and their children to do the same. We should be better able to ensure the well-being of the millions of plant and animal species that share Earth with us, including those as-yet unrecorded species and their potential benefits.

The environmental data needed to associate the causes and effects in biodiversity decline are sparse at best and must be improved. We know little about most insects, arthropods, fungi, bacteria, other soil and sediment microorganisms and marine invertebrates, let alone what comprises healthy populations. We know little about the plants and animals that inhabit the oceans and how marine species are affected by human activities. Less than 30 percent of all species in the United States have been catalogued. Biodiversity assessments help fill the gaps in our scientific knowledge.

Protected Areas

Many protected areas around the world are established with the goal of conserving species and intact natural systems, and help slow the loss of biodiversity. There are numerous examples of such areas – from national and regional parks and forests, wildlife and game preserves, recreation areas, buffer zones and biological corridors to areas dedicated to educational, scientific, and cultural or traditional purposes. In the United States, the National Wilderness Preservation System protects areas that are important as habitat for imperiled species, as watersheds and as scenic and non-motorized recreation areas.

We should keep in mind that populations in small preserves are especially vulnerable to stress from chronic climate change and that their isolation from other populations may actually increase the effects of the stresses. The mere existence of preserves may not be adequate to protect imperiled species. Research into the factors leading to population declines and measures to reduce the impacts is needed, as well as the creation or designation of biological corridors to connect reserves.

Only about 5 percent of the world's land mass is designated as parks or reserves. In countries with limited resources to manage and conserve their biodiversity, a more economical way to improve conservation is to focus on "biodiversity hotspots" —areas with exceptionally high concentrations of endemic species that are suffering high rates of habitat loss. Currently, 25 hotspots containing 44 percent of all known plant species and 35 percent of all known vertebrate species (mammals, amphibians, reptiles) have been identified worldwide. Sixteen of these hotspots are in the tropics where the threats are greatest and conservation capabilities are scarcest. Conservation of

large tracts of remaining humid tropical forest is also essential to protect wide-ranging species whose habitat range exceeds the boundaries of the hotspots.

In many cases, land around reserves is zoned for multiple, sustainable uses. Designated biological corridors allow species to migrate to other protected areas or colonize new patches of habitat. Conservation efforts must respect the rights of indigenous peoples who live close to the areas and often draw their sustenance from resources in the areas. These people are an integral part of the conservation equation.

Ecological Restoration

Ecological restoration is the process of bringing a degraded ecosystem as close as possible back to its original state. It involves recolonization of native plant and animal species and the gradual reestablishment of ecosystem processes such as natural fire cycles.

Terrestrial and aquatic ecological restoration projects are currently in progress across the United States, including Midwestern prairies, Pacific Northwest rivers, Northeastern beaches and the Florida Everglades. However, the cost of restoring habitat can be substantial. It will cost the country an estimated $7.8 billion over the next 36 years to restore the Florida Everglades.

Due to the extent of habitat degradation in the U.S. and around the world, ecological restoration will be a necessary component of biodiversity conservation strategies. However, it should be emphasized that protection of healthy ecosystems is the most cost-effective strategy.

Before: *A Montana creek that cattle have trampled thus damaging stream banks and native vegetation; this has increased sediments and stream temperature that harm fish and other aquatic organisms.*

After: *The restored creek after cattle have been excluded and the native vegetation and physical attributes of the stream restored. An alternative water source has been designated for the cattle and the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program assisted in the private landowner's habitat restoration.*

Botanical Gardens and Zoos

Botanical gardens play an important role as both seed banks and breeding grounds for endangered plant species. Seeds from plants are preserved to ensure that a variety of native plants are available for future cultivation of food crops, medicinal plants and other uses. About 85,000 of the estimated 270,000 species of plants are in cultivation to learn more about their natural history and preserve their genetic stock. Botanical gardens also serve as educational and recreational areas. Like everywhere else, these gardens can be vulnerable to climate change, and may not be able to support necessary levels of genetic diversity. Increased resources and many new gardens may be needed to ensure the survival of large numbers of unrelated individuals and populations of each species.

Zoos are great educational and research institutions. They bring wildlife closer to the general public, and some play an important role in captive breeding. Threatened or endangered species raised and bred outside their natural habitats in zoos and aquariums contribute to captive breeding efforts and therefore to conservation of such species. Captive-bred species have been reintroduced into the wild to increase dwindling populations. Examples include whooping cranes, red wolves, black-footed ferrets, the Arabian oryx and the California condor. There has been some degree of success. Breeding centers do not have the resources or space to accommodate all threatened or endangered species, and scientists still have much to learn about the habitat needs, ecology, biology and social patterns of the animals they are breeding. Sometimes captive-bred animals lack the skills to survive in the wild: they must be taught. Lack of genetic diversity can present great challenges to the effectiveness of captive breeding programs.

Environmental Education

Educating ourselves and our children about the value of biodiversity and how we can protect it may be the salvation of biodiversity for future generations. Government agencies, national and international nonprofit organizations, schools and other academic institutions, zoos, aquariums, museums, botanical gardens, national parks and many other entities are working hard to provide scientifically-based environmental information to citizens so that they can make informed decisions.

Scientific and Industry Collaboration

Sustainable development includes collaboration between scientists and industry to create environmentally friendly projects. Here, scientists from the Smithsonian Institution and their Peruvian counterparts hold an open house on biodiversity at Royal Dutch/Shell Group office in Lima, Peru.

Sustainable Development and Conservation

Sustainable living has been defined as the ability to meet the needs of today's generation without compromising the ability of future generations to meet their needs. Sustainable living does not deplete natural resources or cause declines in biodiversity. It succeeds when governments, non-governmental organizations, scientists, private industry and citizens use their knowledge of the resilience and vulnerabilities of populations and ecosystems to meet economic needs, deal effectively with local and foreign demands for resources, and promote social equity while preserving the ability of natural systems to continue to function. An example of innovative and sustainable development is the new Chesapeake Bay Foundation offices, which feature geothermal heating, composting toilets, solar panels and recycled construction materials.

Solar panels serve as an alternative source of sustainable energy.

In the U.S., where resource consumption is high, adopting a sustainable lifestyle is an important way to benefit biodiversity. Everyday choices such as opting for public transportation, turning off unnecessary lights, choosing organic foods that grow using natural alternatives to pesticides, recycling and reducing the volume of waste produced all contribute to environmental sustainability. At a community and ecosystem level, our decisions about where to live and how we use our resources also make a difference. For example, reserving open spaces within an urbanized area positively affects the ability of some species to persist in the modified landscape. Choosing to create new subdivisions or developments in a sustainable manner – or choosing to create them at all — will impact the long-term ability to maintain the biodiversity and ecosystem functions that support our quality of life. Biodiversity conservation can be compatible with large-scale habitat modifications with proper planning. The challenge is to make choices and develop lifestyles that promote the sustainability of all life – ours, other species, and generations of all to come.

From bird-watching trips in Latin America to photography safaris in Africa and diving trips in Australia and Belize, ecotourism has expanded in recent years as part of the movement toward sustainable development. Ecotourism creates incentives to protect biodiversity and reduce the impacts of development on local ecosystems. As the industry grows, such incentives should increase. Ecotourism also benefits local economies by boosting demand for food, lodging and native guides as well as crafts and other products created by local people.

Legal Measures

Over the years, a series of national and international treaties and conventions have been initiated to protect biodiversity and promote sustainable development. The United States Endangered Species Act calls for the protection and restoration of populations of imperiled species and the habitats on which they depend. The Clean Water and Clean Air Acts help protect the habitat on which plants and animals rely. U.S. legislation also guides management of national parks, forests, refuges and marine sanctuaries, in part for biodiversity conservation. International treaties include the 1992 Convention on Biological Diversity, drawn up at the United Nations Conference on Environment and Development, and the 1975 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The Convention on Biological Diversity became international law in 1993, but the United States has not become a member.

Trade of the Showy Lady's Slipper Orchid is regulated by the international convention CITES.

V. Protecting Biodiversity in North America

In the United States, Canada and Mexico, national parks, forests, grasslands, refuges and other public lands present an opportunity to protect biodiversity and provide the public with many other services. As examples, prairie restoration is occurring in some Midwestern parks. Introduced goats that destroy native plants are being removed from national parks in Hawaii. Experts are raising peregrine falcons in the wild to re-establish the bird's populations in Rocky Mountain National Park in Colorado. Park employees are screening off sea turtle nesting sites from predators and other disturbances at Cape Canaveral, Cape Lookout, Cape Hatteras and other areas along the Atlantic Coast and Gulf of Mexico.

The United States

The U.S. Department of Agriculture's Forest Service administers national forests and grasslands, which combined comprise 10 percent of the total area of the United States. Legislation requires that these areas provide for a diversity of plant and animal communities and be maintained for multiple uses, including outdoor recreation, rangeland, watershed protection, wildlife and fish protection, and timber extraction. The U.S. Department of Defense manages nationally protected land, both on military bases and in Army Corps of Engineers recreation areas.

The National Wildlife Refuge System encompasses 3.4 percent of the United States, with the largest refuges in Alaska. The refuge system protects plants, fish, waterfowl and other species, including two-thirds of all U.S. mammals, more than one-half of all U.S. birds and two-fifths of all U.S. reptiles and amphibians. The Fish and Wildlife Service's Endangered Species Program officially identifies and lists threatened or endangered species and develops recovery plans.

The Bureau of Land Management (BLM) administers more than 12 percent of the total U.S. land area, primarily in the western portion of the country and Alaska. These lands are managed mostly for multiple use, including livestock grazing, mineral and timber extraction, wildlife protection and recreation. Many threatened or endangered plant and animal species are located on BLM lands. Similarly tribal lands, again primarily in the West, serve to protect a portion of our national biodiversity heritage.

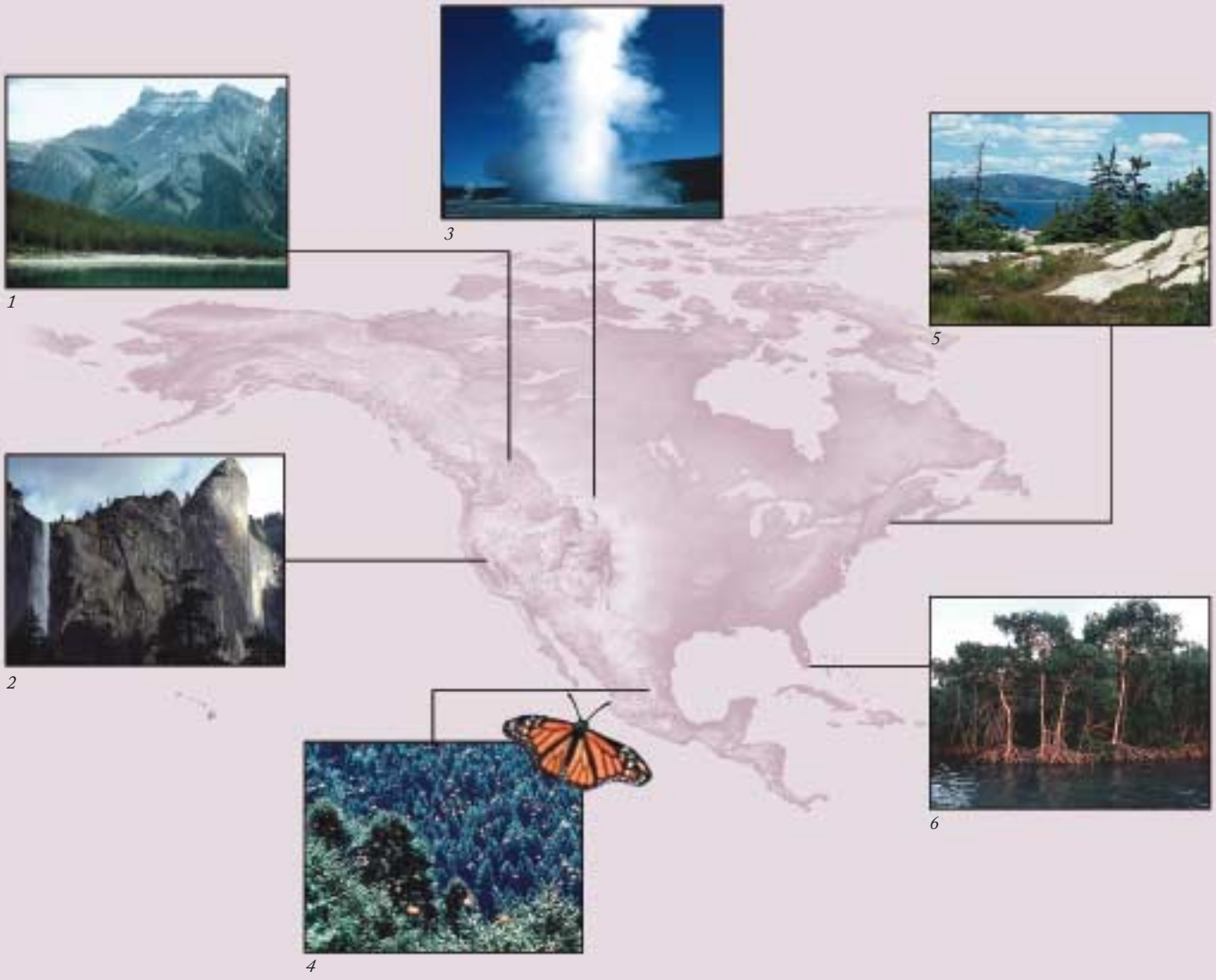
The National Park Service is responsible for 378 national park units in 49 states, the District of Columbia, and 5 U.S. territories. These units include Yellowstone National Park, which Congress established in 1872 as the first national park in the world. State-run parks cover more than 11.6 million acres and host 725,500,000 visitors annually.

Private reserves managed by groups such as The Nature Conservancy, National Audubon Society and the Land Trust Alliance also contribute to biodiversity conservation. The Land Trust Alliance alone has assisted in the acquisition or classification of 4 million acres of private lands to be protected as conservation easements or land trusts.

Canada and Mexico

Canada has a similar system of protected areas, including wildlife areas, recreation areas, wilderness areas, ecological reserves, and national, provincial and regional parks. Mexico maintains a system of protected natural areas with funding from sources such as the Global Environment Fund channeled through the Mexican Nature Conservation Fund. In 1992, the President of Mexico established the National Commission for the Knowledge and Use of Biodiversity (CONABIO) to coordinate conservation and research efforts designed to preserve biological resources. CONABIO focuses on research, sustainable use and public awareness.

Biodiversity in North America



1. *Home to grizzly bear, caribou, and wolves, Banff National Park in Alberta, Canada protects biodiversity in the Canadian Rockies.*
2. *Beautiful waterfalls and groves of giant sequoias – among the world's largest living things – are found in Yosemite National Park in California.*
3. *Millions of visitors are attracted to Yellowstone National Park for its famous geyser, Old Faithful, and its diverse wildlife including wolves, trumpeter swans, bison and grizzly bear.*
4. *Monarch butterflies migrate to the forests of the Monarch Butterfly Special Biosphere Reserve in Michoacan, Mexico to spend the winter months.*
5. *Acadia National Park protects some of Maine's natural treasures including spectacular coastline, mountains, woodlands and lakes.*
6. *Mangroves in Florida's Everglades National Park serve as nurseries for a multitude of marine species and as habitat for alligators and sea birds.*

What you can do to help

Because most people around the world live in cities, it is easy for us to forget the origin of our resources. But cities and the people in them depend on giant tracts of land for food, water, transportation, clothes, wood for construction and many other needs. The average U.S. citizen relies on 25 acres (the size of 25 football fields) to support her or his lifestyle. However, worldwide, the biologically productive space available per person is only 5.4 acres. This is referred to as an "ecological footprint." To determine your footprint, visit <*www.lead.org/leadnet/footprint/default.htm*> on the Internet.

While it may sound like an overworked message, it is true that the individual actions we all take make a difference when it comes to conserving biodiversity. You've already taken one step in the right direction by reading this booklet. Other steps include:

Live a more sustainable life:

- Walk, bike, carpool and/or take public transportation.
- Recycle. Take your own bags and containers to the grocery store and to restaurants when you order to go. Take your own mug to the coffee shop.
- Compost. Much of our organic waste does not need to fill up landfills.
- Conserve water. Water your lawn at night and take shorter showers.
- Purchase food and wood products made from crops and trees that are grown and harvested in a sustainable manner.
- Grow a pollinator-friendly garden in your backyard or school grounds. Plant species native to your area.

Continue to read, ask questions and visit museums, botanical gardens, zoos and aquariums, which sponsor educational programs.

Contact your state invasive weed and plant officials to learn how you can help stop the spread of these pests. Don't plant exotic plants and seeds in your gardens.

Share what you learn with your children, your parents, your coworkers, your friends and your neighbors.

Support biodiversity conservation efforts.

Travel, learn and engage people from other cultures to gain an appreciation of how they value, protect and depend on biodiversity.

Consider careers in biodiversity sciences and policy such as marine biologist, field ecologist, zoologist, environmental lawyer, environmental educator, environmental economist, and many others.

Each of us makes choices that will affect generations to come. The future of Earth's biodiversity depends on those choices.

Where to go for more information

Local and Regional Biodiversity. *City zoos, botanical gardens, science museums, local chapters of national and state conservation organizations, national forests and wildlife refuges, Bureau of Land Management, state and national parks.*

For additional information please contact Smithsonian Institution Monitoring & Assessment of Biodiversity Program at:
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This publication is also available through: <www.si.edu/simab>

Other organizations interested in biodiversity:

North American Biodiversity

Animal Diversity Web
Canadian Nature Federation
Center for Marine Conservation
Defenders of Wildlife
Mexican Biodiversity Commission
Mexican Nature Conservation Fund
National Audubon Society
National Fish and Wildlife Federation
National Invasive Species Council
National Wildlife Federation
Natural Resources Defense Council
The Nature Conservancy
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. National Marine Fisheries Services
The Wilderness Society
The Wildlands Project
Wildlife Conservation Society
World Wildlife Fund, U.S.

Global Biodiversity

Conservation International
Convention on Biological Diversity, Secretariat
Ecological Society of America
The World Conservation Union
Latin American Alliance Biodiversity Overview
Marine Conservation Biology Institute
United Nations Environment Programme
Virtual Library of Ecology and Biodiversity

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