

Biodiversity

A World Rich in Biodiversity

Biodiversity, short for biological diversity, is the variety of organisms in a given area, the genetic variation within a population, the variety of species in a community, or the variety of communities in an ecosystem.

Certain areas of the planet, such as tropical rainforests, contain an extraordinary variety of species.

Humans need to understand and preserve biodiversity for our own survival.



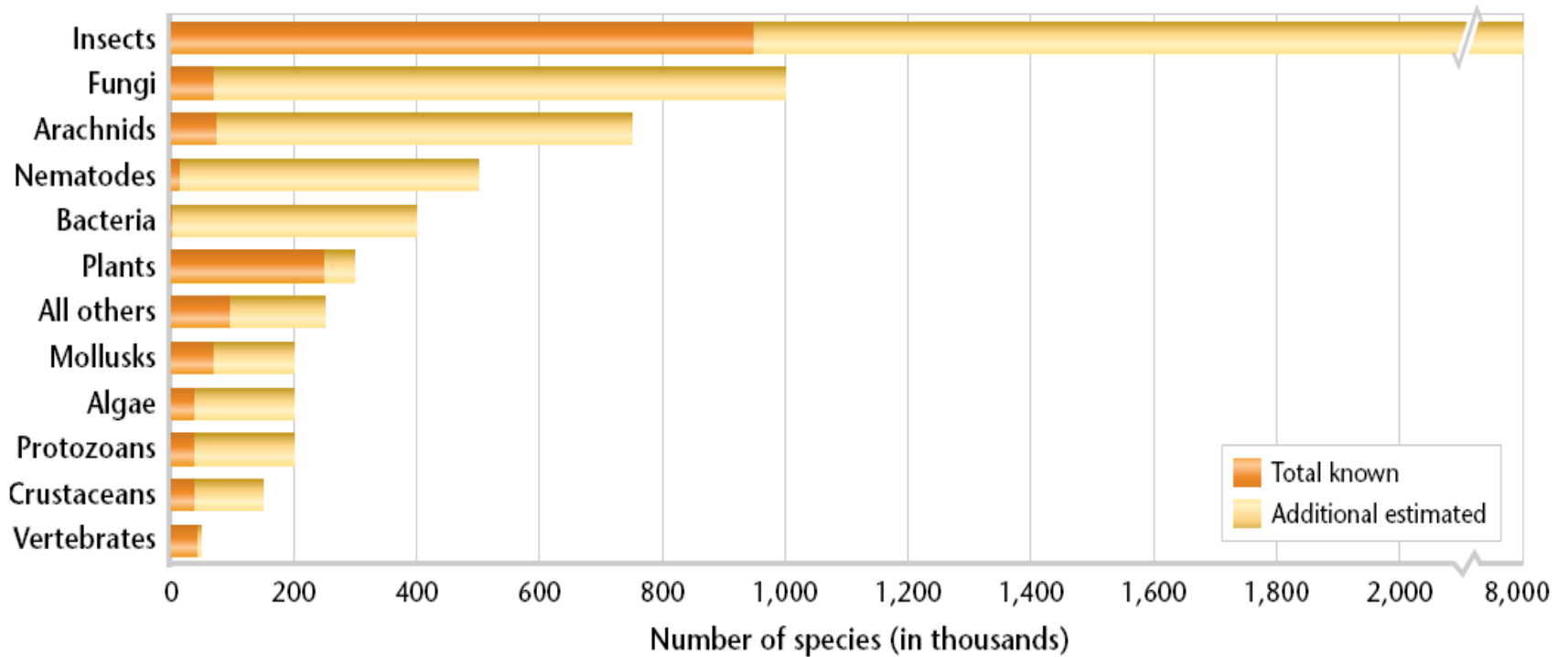
Unknown Diversity

The study of biodiversity starts with the unfinished task of cataloging all the species that exist on Earth.

The number of species known to science is about 1.7 million, most of which are insects. However, the actual number of species on Earth is unknown.

Scientists accept an estimate of greater than 10 million for the total number of species.

Unknown Diversity



Unknown Diversity

New species are considered known when they are collected and described scientifically.

Unknown species exist in remote wilderness, deep oceans, and even in cities.

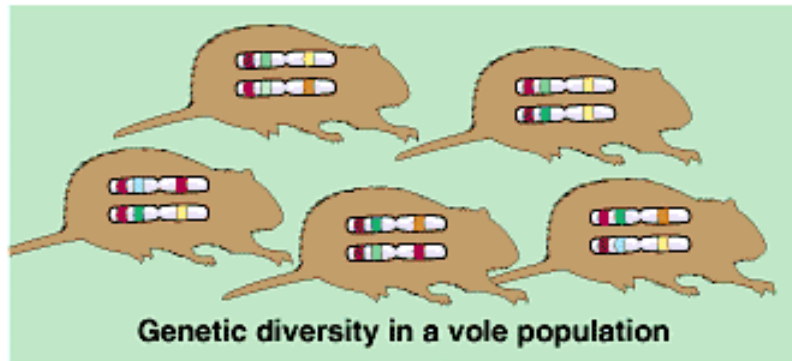
Some types of species are harder to study and receive less attention than large, familiar species.

Levels of Diversity

Biodiversity can be studied and described at three levels: species diversity, ecosystem diversity, and genetic diversity.

Species diversity refers to all the differences between populations of species, as well as between different species.

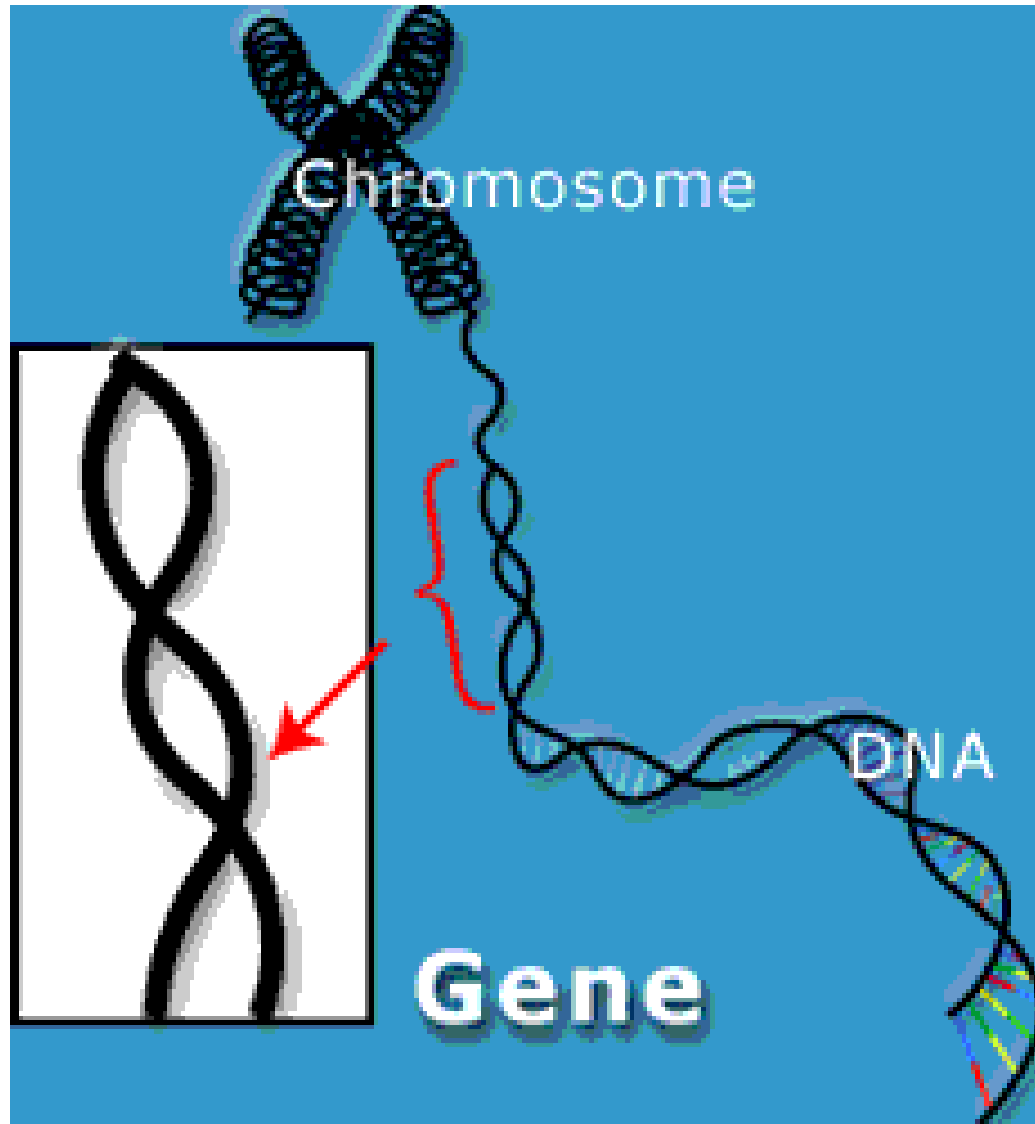
Ecosystem diversity refers to the variety of habitats, communities, and ecological processes within and between ecosystems.



Levels of Diversity

Genetic diversity refers to all the different genes contained within all members of a population.

A **gene** is a segment of DNA that is located in a chromosome and that codes for a specific hereditary trait.



Benefits of Biodiversity

Biodiversity can affect the stability of ecosystems and the sustainability of populations.

We depend on healthy ecosystems to ensure a healthy biosphere that has balanced cycles of energy and nutrients.

Species are part of these cycles.

Species Are Connected to Ecosystems

When scientists study any species closely, they find that it plays an important role in an ecosystem.

Every species is probably either dependent on or depended upon by at least one other species in ways that are not always obvious.

When one species disappears from an ecosystem, a strand in a food web is removed.

Species Are Connected to Ecosystems

Some species are clearly critical to the functioning of an ecosystem.

A **keystone species** is a species that is critical to the functioning of the ecosystem in which it lives because it affects the survival and abundance of many other species in its community.

An example is the sea otter. The loss of the sea otter populations led to an unchecked sea urchin population, which ate all the kelp leading to the loss of kelp beds along the U.S. Pacific Coast.



Species and Population Survival

The level of genetic diversity within populations is a critical factor in species survival.

Genetic variation increases the chances that some members of the population may survive environmental pressures or changes.

Small and isolated populations are less likely to survive such pressures.

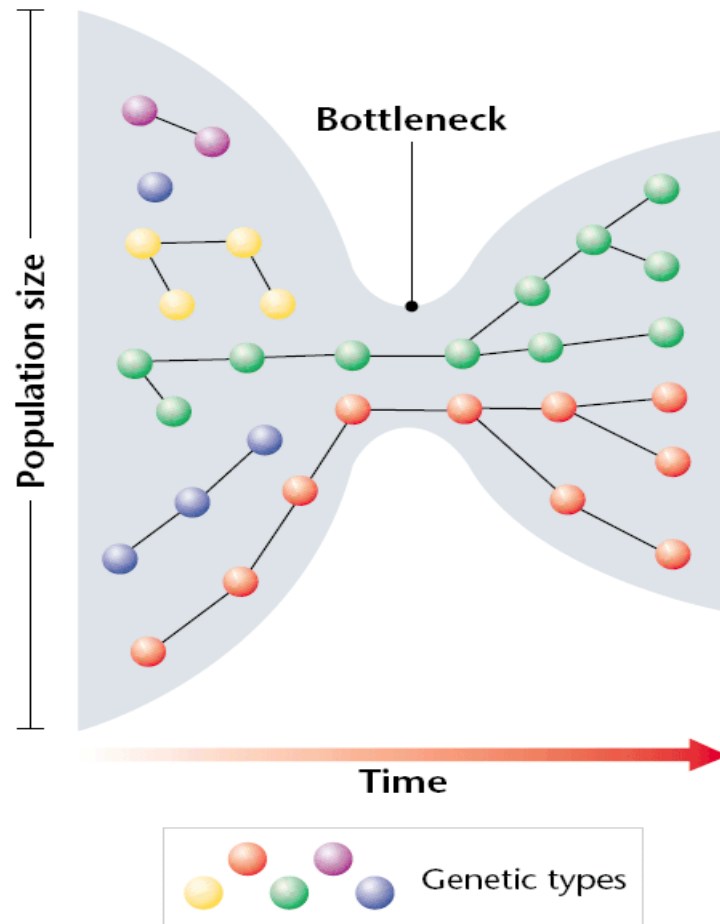
Species and Population Survival

When a population shrinks, its genetic diversity decreases as though it is passing through a bottleneck.

Even if such a population is able to increase again, there will be inbreeding within a smaller variety of genes.

The members of the population may then become more likely to inherit genetic diseases.

Species and Population Survival



Medical and Industrial Uses

About one quarter of the drugs prescribed in the United States are derived from plants, and almost all of the antibiotics are derived from chemicals found in fungi.

New chemicals and industrial materials may be developed from chemicals discovered in all kinds of species.

The scientific community continues to find new uses for biological material and genetic diversity.

Medical Uses

Common Medicines Derived from Plants		
Medicine	Origin	Use
Neostigmine	calabar bean (Africa)	treatment of glaucoma and basis for synthetic insecticides
Turbocurarine	curare vine (South America)	surgical muscle relaxant; treatment of muscle disorders; and poison for arrow tips
Vincristine, vinblastine	rosy periwinkle (Madagascar)	treatment of pediatric leukemia and Hodgkin's disease
Bromelain	pineapple (South America)	treatment to control tissue inflammation
Taxol	Pacific yew (North America)	anticancer agent
Novacaine, cocaine	coca plant (South America)	local anesthetic and basis for many other anesthetics
Cortisone	wild yam (Central America)	hormone used in many drugs
L-dopa (levodopa)	velvet bean (tropical Asia)	treatment of Parkinson's disease
Reserpine	Indian snakeroot (Malaysia)	treatment to reduce high blood pressure

Agricultural Uses

Most of the crops produced around the world originated from a few areas of high biodiversity.

Most new crop varieties are hybrids, or crops developed by combining genetic material from other populations.

History has shown that depending on too few plants for food is risky. Famines have resulted when an important crop was wiped out by disease. But some crops have been saved by crossbreeding them with wild plant relatives.

Agricultural Uses

Origins of Some Foods

North America, Central America, and South America

- corn (maize), tomato, bean (pinto, green, and lima), peanut, potato, sweet potato, avocado, pumpkin, pineapple, cocoa, vanilla, and pepper (green, red, and chile)

Northeastern Africa, Central Asia, and Near East

- wheat (several types), sesame, chickpea, fig, lentil, carrot, pea, okra, date, walnut, coffee, cow, goat, pig, and sheep

India, East Asia, and Pacific Islands

- soybean, rice, banana, coconut, lemon, lime, orange, cucumber, eggplant, turnip, tea, black pepper, and chicken

Ethics, Aesthetics, and Recreation

Some people believe that we should preserve biodiversity for ethical reasons. They believe that species and ecosystems have a right to exist whether or not they have any other value.

People also value biodiversity for aesthetic or personal enjoyment such as keeping pets, camping, picking flowers, or watching wildlife.

Ecotourism is a form of tourism that supports the conservation and sustainable development of ecologically unique areas.

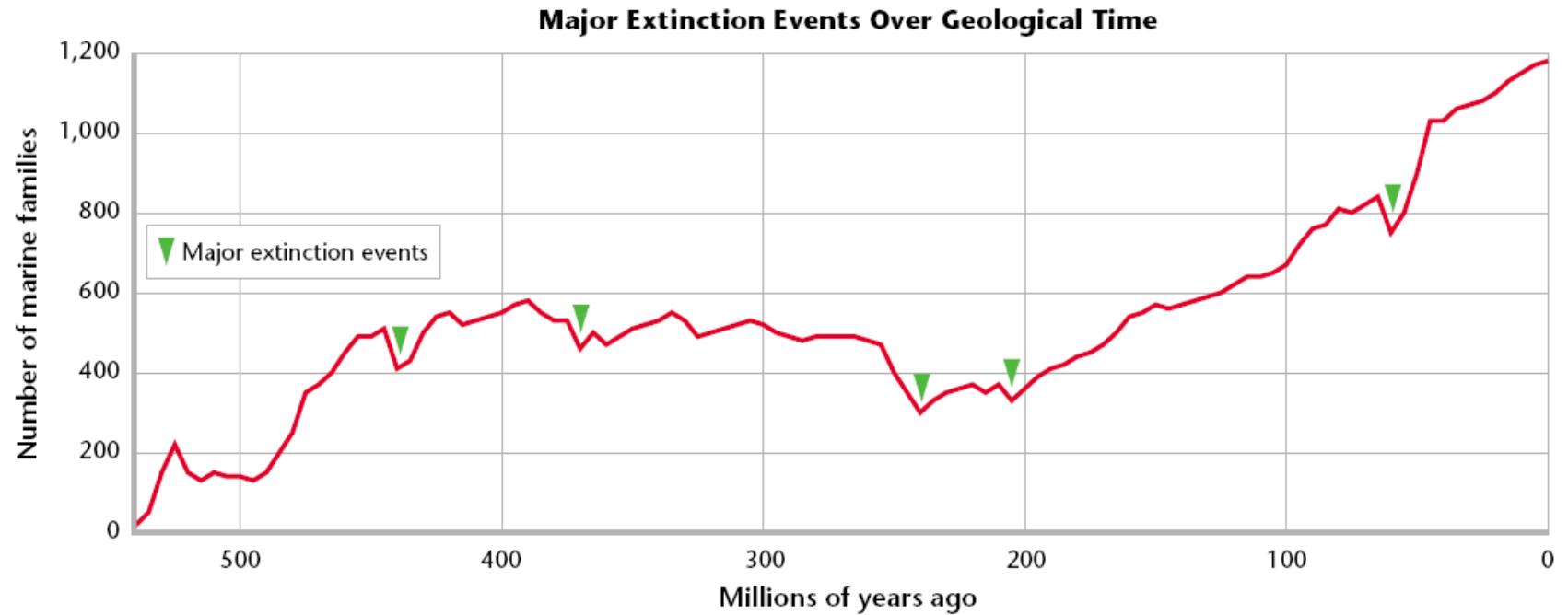
Biodiversity at Risk

The extinction of many species in a relatively short period of time is called a **mass extinction**.

Earth has experienced several mass extinctions, each probably caused by a global change in climate.

It takes millions of years for biodiversity to rebound after a mass extinction.

Biodiversity at Risk

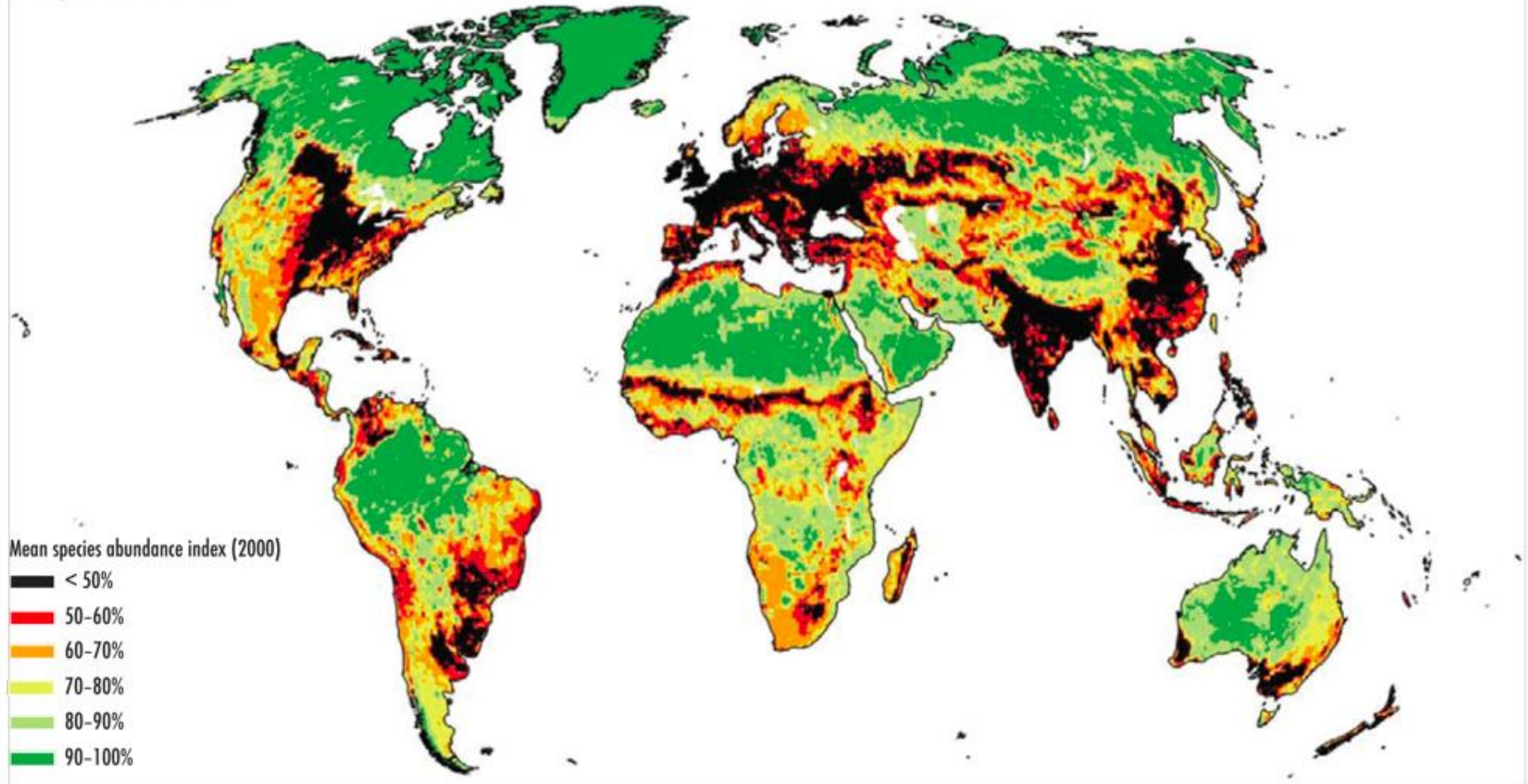


Defining and measuring biodiversity

Biodiversity as defined by the Convention on Biological Diversity encompasses the diversity of genes, species and ecosystems. One terrestrial measure of species-level diversity is the average remaining abundance of each individual species belonging to an ecosystem, or “mean original species abundance” (MSA). MSA represents the remaining abundance of native species, relative to a natural state. For example, if a

forest is cleared, then the MSA is based on the surviving forest species. MSA is modelled on a relative scale from 0 per cent (ecosystem destroyed) to 100 per cent (ecosystem intact).

Mean species abundance in 2000



Current Extinctions

Scientists are warning that we are in the midst of another mass extinction.

The rate of extinctions is estimated to have increased by a multiple of 50 since 1800, with up to 25 percent of all species on Earth becoming extinct between 1800 and 2100.

The current mass extinction is different from those of the past because humans are the primary cause of the extinctions.

Species Prone to Extinction

Large populations that adapt easily to many habitats are not likely to become extinct.

However, small populations in limited areas can easily become extinct.

Species that are especially at risk of extinction are those that migrate, those that need large or special habitats, and those that are exploited by humans.

Species Prone to Extinction

An **endangered species** is a species that has been identified to be in danger of extinction throughout all or a significant part of its range, and that is thus under protection by regulations or conservation measures.

A **threatened species** is a species that has been identified to be likely to become endangered in the foreseeable future.

How Do Humans Cause Extinctions?

In the past 2 centuries, human population growth has accelerated and so has the rate of extinctions.

The numbers of worldwide species known to be threatened, endangered, or recently extinct are listed on the next slide.

The major causes of extinction today are the destruction of habitats, the introduction of nonnative species, pollution, and the overharvesting of species.

How Do Humans Cause Extinctions?

Species Known to Be Threatened or Extinct Worldwide

Type of species	Number threatened (all categories of risk)	Number extinct (since ~1800)	Percent of species that may be threatened
Mammals	1,130	87	26
Birds	1,183	131	12
Reptiles	296	22	3.3
Amphibians	146	5	3.1
Fishes	751	92	3.7
Insects	555	73	0.054
Other crustaceans	555	73	1.03
Mollusks and worms	944	303	1.3
Plants	30,827	400	0.054



Habitat Destruction and Fragmentation

As human populations grow, we use more land to build homes and harvest resources.

In the process, we destroy and fragment the habitats of other species.

It is estimated that habitat loss causes almost 75 percent of the extinctions now occurring.

Habitat Destruction and Fragmentation

For example, cougars, including the Florida Panther, require expansive ranges of forest and large amount of prey.

Today, much of the cougars' habitat has been destroyed or broken up by roads, canals, and fences.

In 2001, fewer than 80 Florida panthers made up the only remaining wild cougar population east of the Mississippi River.

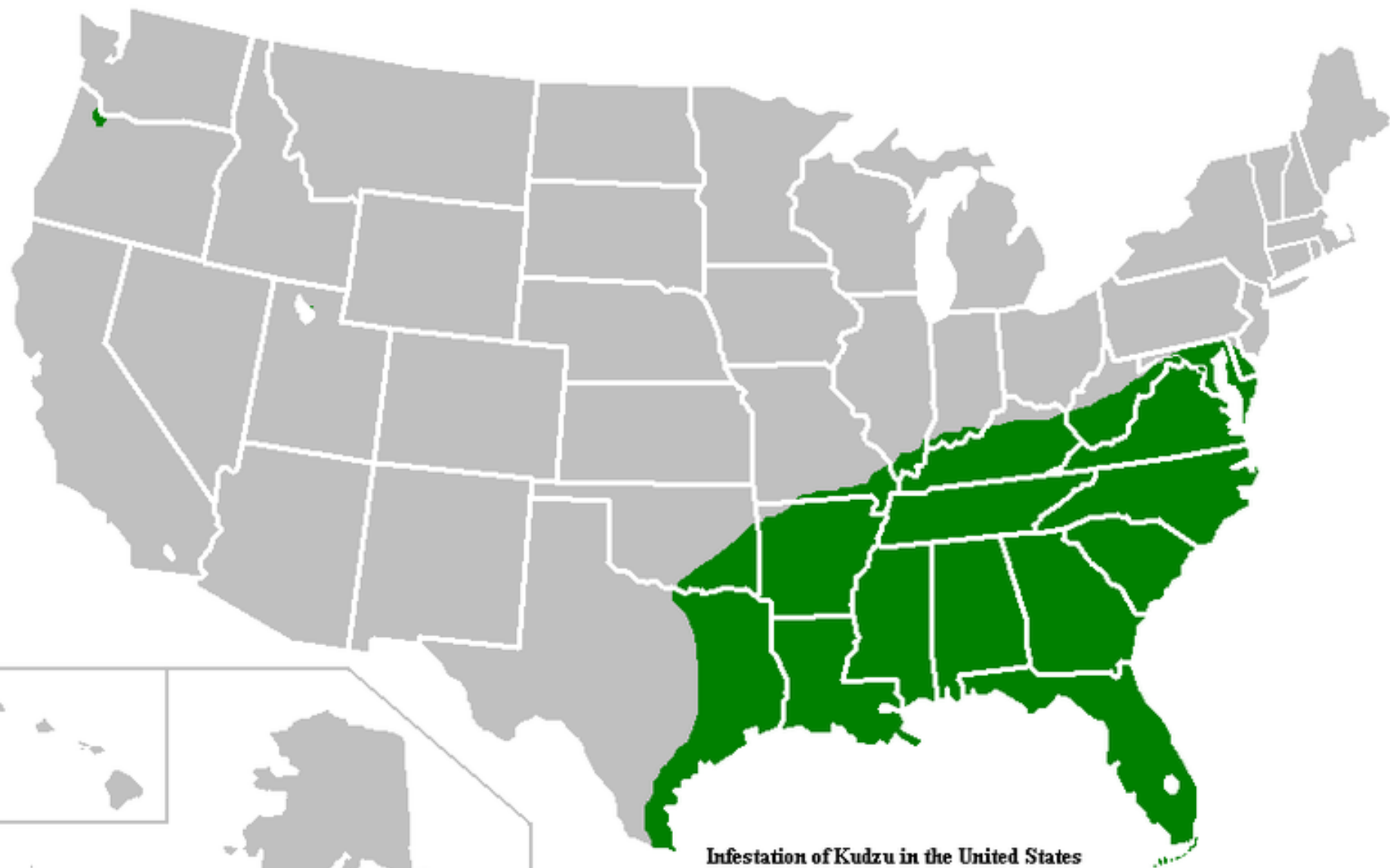


Invasive Exotic Species

An **exotic species** is a species that is not native to a particular region.

Even familiar organisms such as cats and rats are considered to be exotic species when they are brought to regions where they never lived before.

Exotic species can threaten native species that have no natural defenses against them.



Infestation of Kudzu in the United States



Harvesting, Hunting, and Poaching

Excessive hunting can also lead to extinction as seen in the 1800s and 1900s when 2 billion passenger pigeons were hunted to extinction.

Thousands of rare species worldwide are harvested and sold for use as pets, houseplants, wood, food, or herbal medicine.

Poaching is the illegal harvesting of fish, game, or other species.



Pollution

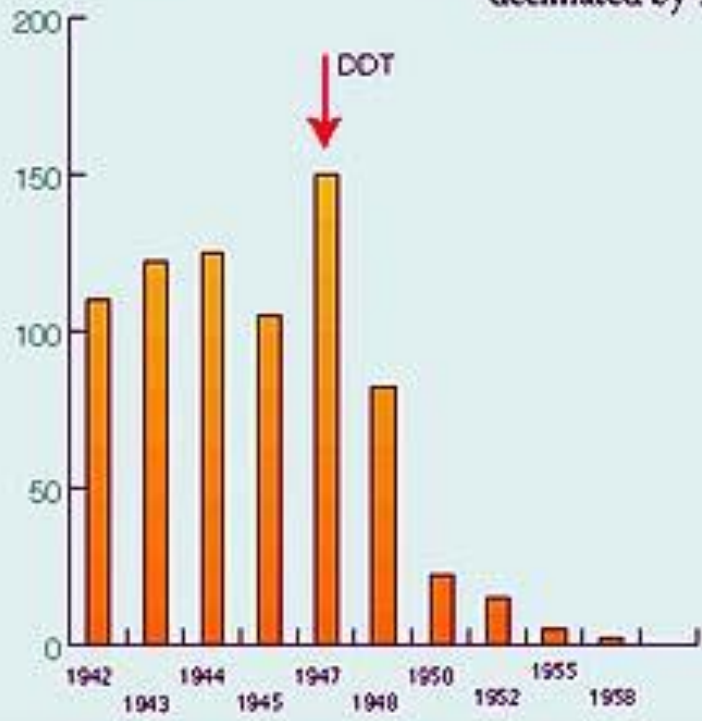
Pesticides, cleaning agents, drugs, and other chemicals used by humans are making their way into food webs around the globe.

The long term effects of chemicals may not be clear until after many years.

The bald eagle was endangered because of a pesticide known as DDT. Although DDT is now illegal to use in the United States, it is still manufactured here and used around the world.

Number of nesting Florida Bald Eagles

Eagle Population in Florida decimated by DDT



Areas of Critical Biodiversity

An important feature of areas of the world that contain greater diversity of species is that they have a large portion of endemic species.

An **endemic species** is a species that is native to a particular place and that is found only there.

Ecologists often use the numbers of endemic species of plants as an indicator of overall biodiversity because plants form the basis of ecosystems on land.

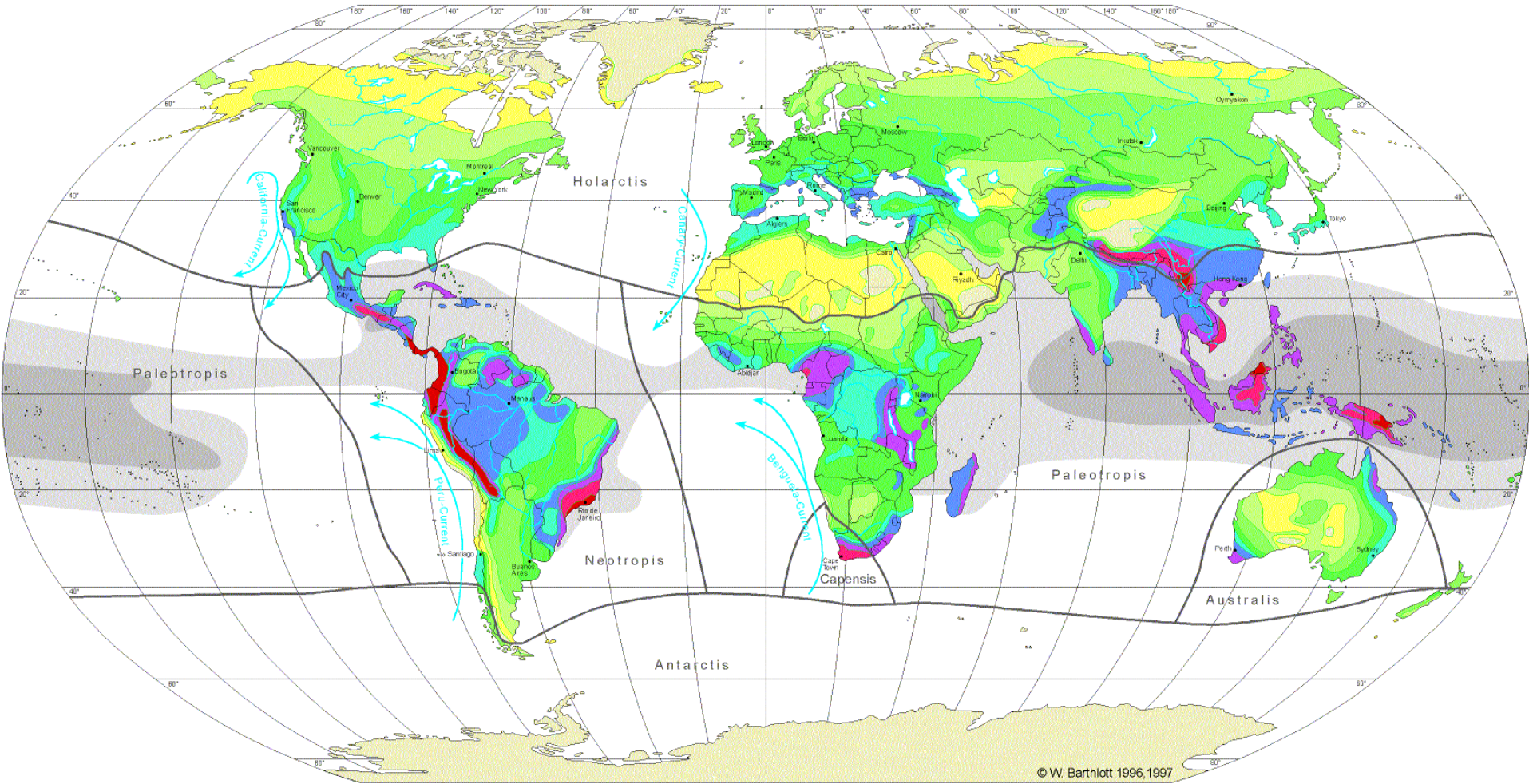
Tropical Rain Forests

Biologists estimate that over half of the world's species live in these forests even though they cover only 7 percent of the Earth's land surface.

Most of the species have never been described. Unknown numbers of these species are disappearing as tropical forests are cleared for farming or cattle grazing.

Tropical forests are also among the few places where some native people maintain traditional lifestyles.

GLOBAL BIODIVERSITY: SPECIES NUMBERS OF VASCULAR PLANTS



© W. Barthlott 1996, 1997


Robinson Projection
Standard Parallels 38°N und 38°S
Scale 1: 130 000 000

Diversity Zones (DZ): Number of species per 10.000km²



sea surface temperature



 cold currents

W. Barthlott, N. Biedinger, G. Braun
F. Feig, G. Kier, W. Lauer & J. Mutke 1997
modified after

W. Barthlott, W. Lauer & A. Placke 1996
Department of Botany and Geography
University of Bonn

German Aerospace Research Establishment, Cologne

Cartography: M. Gref
Department of Geography
University of Bonn

Coral Reefs and Coastal Ecosystem

Reefs provide millions of people with food, tourism revenue, coastal protection, and sources of new chemicals, but are poorly studied and not as well protected by laws as terrestrial areas are.

Nearly 60 percent of Earth's coral reefs are threatened by human activities, such as pollution, development along waterways, and overfishing.

Similar threats affect coastal ecosystems, such as swamps, marshes, shores, and kelp beds.





Islands

When an island rises from the sea, it is colonized by a limited number of species from the mainland. These colonizing species may then evolve into several new species.

Thus, islands often hold a very distinct but limited set of species.

Many island species, such as the Hawaiian honeycreeper, are endangered because of invasive exotic species.

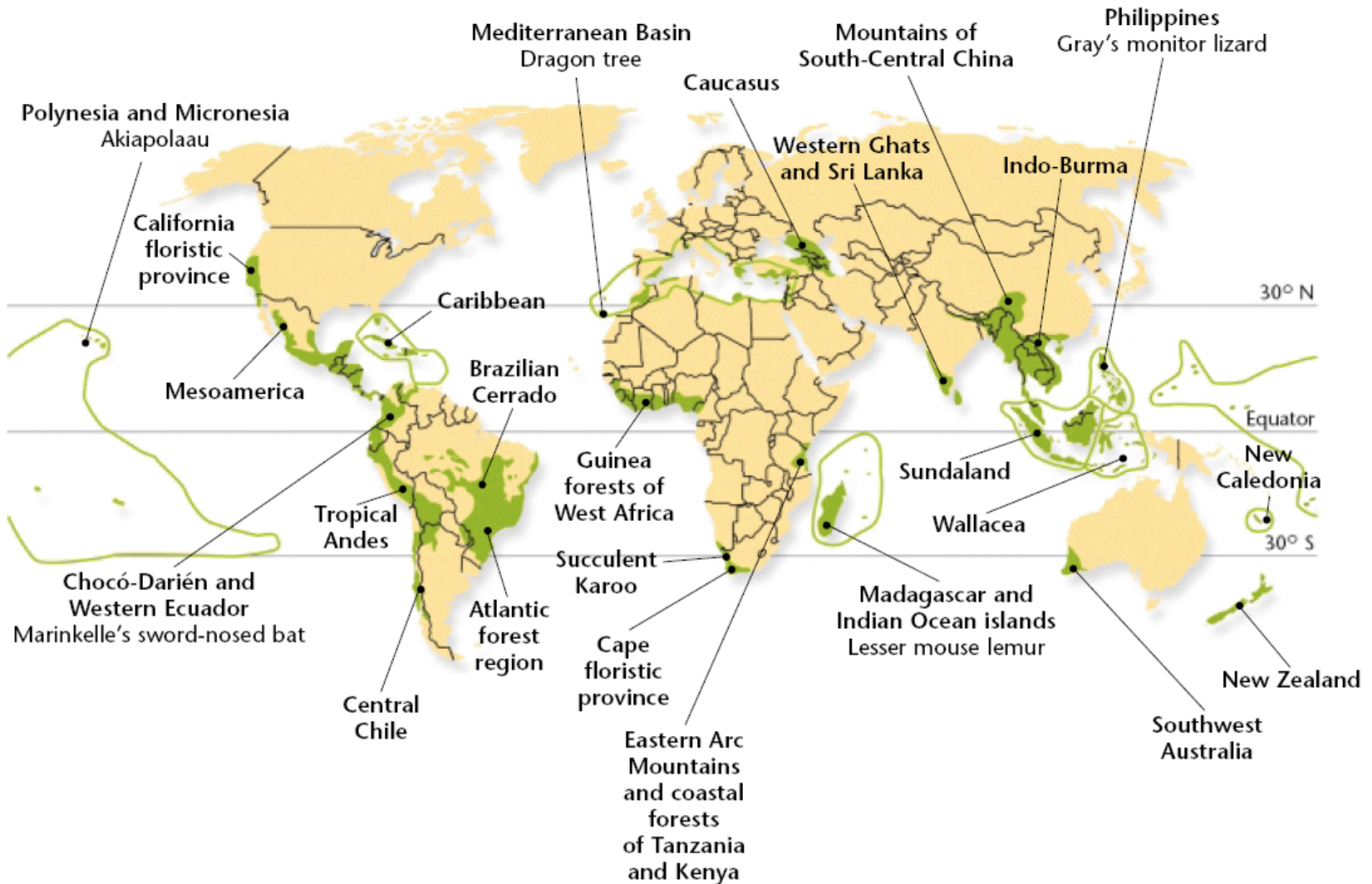
Biodiversity Hotspots

The most threatened areas of high species diversity on Earth have been labeled **biodiversity hotspots** and include mostly tropical rainforests, coastal areas, and islands.

The hotspot label was developed by an ecologist in the late 1980s to identify areas that have high numbers of endemic species but that are also threatened by human activities.

Most of these hotspots have lost at least 70 percent of their original natural vegetation.

Biodiversity Hotspots



Hot Spots of Rarity and Richness



Source: *Precious Heritage* (2000) © TNC, ABI

Biodiversity in the United States

The United States includes a wide variety of unique ecosystems, including the Florida Everglades, the California coastal region, Hawaii, the Midwestern prairies, and the forests of the Pacific Northwest.

The United States holds unusually high numbers of species of freshwater fishes, mussels, snails, and crayfish. Diversity is also high among groups of the land plants such as pine trees and sunflowers.

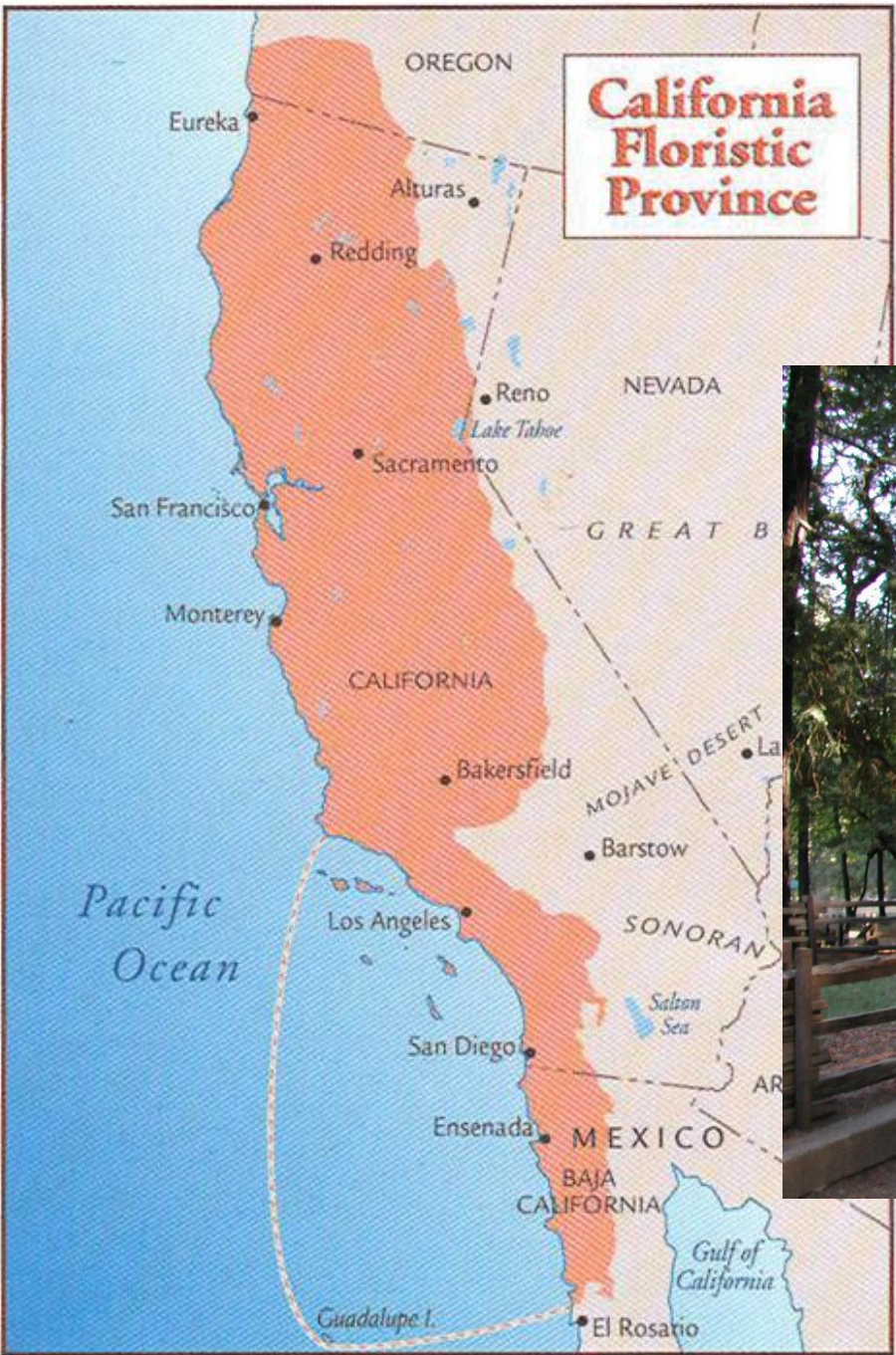


Biodiversity in the United States

The California Floristic Province, a biodiversity hotspot, is home to 3,488 native plant species.

Of these species, 2,124 are endemic and 565 are threatened or endangered.

The threats to this area include the use of land for agriculture and housing, dam construction, overuse of water, destructive recreation, and mining. All of which stem from local human population growth.



California Floristic Province



Sources: Raven and Axelrod and Rancho Santa Ana Botanic Garden.

Saving Species One at a Time

When a species is clearly on the verge of extinction, concerned people sometimes make extraordinary efforts to save the last few individuals.

These people hope that a stable population may be restored someday.

Methods to preserve individual species often involve keeping and breeding the species in captivity.

Captive-Breeding Programs

Wildlife experts may attempt to restore the population of a species through captive-breeding programs.

These programs involve breeding species in captivity, with the hopes of reintroducing populations to their natural habitats.

This type of program has been used successfully with the Californian condor, for example. But the question remains whether or not these restored populations will ever reproduce in the wild.



Preserving Genetic Material

One way to save the essence of a species is by preserving its genetic material.

Germ plasm is hereditary material (chromosomes and genes) that is usually contained in the protoplasm of germ cells and may be stored as seeds, sperm, eggs, or pure DNA.

Germ-plasm banks store germ plasm in controlled environments for future use in research or species-recovery efforts.



Zoos, Aquariums, Parks, and Gardens

In some cases, zoos now house the few remaining members of a species and are perhaps the species' last hope for survival.

Zoos, wildlife parks, aquariums, and botanical gardens, are living museums of the world's biodiversity.

But, these kinds of facilities rarely have enough resources or knowledge to preserve more than a fraction of the world's rare and threatened species.



More Study Needed

Ultimately, saving a few individuals does little to preserve a species as captive species may not reproduce or survive again in the wild.

Also, small populations are vulnerable to infectious diseases and genetic disorders caused by inbreeding.

Conservationists hope that these strategies are a last resort to save species.

Preserving Habitats and Ecosystems

The most effective way to save species is to protect their habitats.

Small plots of land for a single population is usually not enough because a species confined to a small area could be wiped out by a single natural disaster. While other species require a large range to find adequate food.

Therefore, protecting the habitats of endangered and threatened species often means preserving or managing large areas.

Conservation Strategies

Most conservationists now give priority to protecting entire ecosystems rather than individual species.

By doing this, we may be able to save most of the species in an ecosystem instead of only the ones that have been identified as endangered.

The general public has now begun to understand that Earth's biosphere depends on all its connected ecosystems.

Conservation Strategies

While conservationists focus on the hotspots discussed earlier to protect biodiversity worldwide, they also support additional strategies.

One strategy is to identify areas of native habitat that can be preserved, restored, and linked into large networks.

Another promising strategy is to promote products that have been harvested with sustainable practices.



**WILDLIFE
CONSERVATION:
PROTECTING OUR**

*Vanishing
Wildlife*



More Study Needed

Conservationists emphasize the urgent need for more serious study of the workings of species and ecosystems.

Only in recent decades has there been research into basic questions as, How much fragmentation can a particular ecosystem tolerate?

The answers to questions asked now may be years or decades away, but decisions affecting biodiversity continue to be made based on available information.

Legal Protection for Species

Many nations have laws and regulations designed to prevent the extinction of species, and those in the United States are among the strongest.

For example, in 1973, the U.S. Congress passed the Endangered Species Act.

The **Endangered Species Act** is designed to protect any plant or animal species in danger of extinction.

U.S. Laws

Under the first provision of the Endangered Species Act, the U.S. Fish and Wildlife Service (USFWS) must compile a list of all endangered and threatened species in the United States. As of 2002, 983 species of plants and animals were listed.

The second main provision of the act protects listed species from human harm.

The third provision prevents the federal government from carrying out any project that jeopardizes a listed species.

[Endangered Species of North America List](#)

Major Provisions of the Endangered Species Act

- The U.S. Fish and Wildlife Service (USFWS) must compile a list of all endangered and threatened species.
- Endangered and threatened animal species may not be caught or killed. Endangered and threatened plants on federal land may not be uprooted. No part of an endangered and threatened species may be sold or traded.
- The federal government may not carry out any project that jeopardizes endangered species.
- The U.S. Fish and Wildlife Service must prepare a species recovery plan for each endangered and threatened species.

Recovery Plans

Under the fourth main provision of the Endangered Species Act, the USFWS must prepare a species recovery plan for each listed species. These plans often propose to protect or restore habitat for each species.

However, attempts to restrict human uses of land can be controversial. Real-estate developers may be prohibited from building in certain areas, and people may lose income and may object when their interests are placed below those of another species.

Habitat Conservation Plans

Battles between environmentalists and developers are widely publicized, and in most cases, compromises are eventually worked out. One form of compromise is a habitat conservation plan.

A **habitat conservation plan** is a land-use plan that attempts to protect threatened or endangered species across a given area by allowing some tradeoffs between harm to the species and additional conservation commitments among cooperating parties.

International Cooperation

At the global level, the International Union for the Conservation of Nature and Natural Resources (IUCN) facilitates efforts to protect species and habitats.

The IUCN publishes *Red Lists* of species in danger of extinction around the world, advises governments on ways to manage their natural resources, and works with groups like the World Wildlife Fund to sponsor projects such as attempting to stop poaching in Uganda.

International Trade and Poaching

One product of the IUCN has been an international treaty called CITES (the Convention on International Trade in Endangered Species).

The CITES treaty was the first effective effort to stop the slaughter of African elephants being killed by poachers who would then sell the ivory tusks.

In 1989, the members of CITES proposed a total worldwide ban on all sales, imports, and exports of ivory, hoping to put a stop to the problem.

International Trade and Poaching

Some people worried that making ivory illegal might increase the rate of poaching instead of decrease it.

They argued that illegal ivory, like illegal drugs, might sell for a higher price.

But after the ban was enacted, the price of ivory dropped, and elephant poaching declined dramatically.

The Biodiversity Treaty

One of the most ambitious efforts to tackle environmental issues on a worldwide scale was the United Nations Conference on Environment and Development, also known as the first *Earth Summit*. An important result of the Earth Summit was the Biodiversity Treaty.

The **Biodiversity Treaty** is an international agreement aimed at strengthening national control and preservation of biological resources.

The Biodiversity Treaty

The treaty's goal is to preserve biodiversity and ensure the sustainable and fair use of genetic resources in all countries.

However, the treaty took several years to be adopted into law by the U.S. government.

Some political groups objected to the treaty, especially to the suggestion that economic and trade agreements should take into account any impacts on biodiversity that might result from the agreements.

Private Conservation Efforts

Many private organizations work to protect species worldwide, often more effectively than government agencies.

For example, the World Wildlife Fund encourages the sustainable use of resources and supports wildlife protection. The Nature Conservancy has helped purchase millions of hectares of habitat preserves in 29 countries. Conservation International helps identify biodiversity hotspots. And, Greenpeace International organizes direct and sometimes confrontational actions.

Balancing Human Needs

Attempts to protect species often come into conflict with the interests of the world's human inhabitants.

An endangered species might represent a source of food or income. Or a given species may not seem valuable to those who do not understand the species' role in an ecosystem.

Many conservationists feel that an important part of protecting species is making the value of biodiversity understood by more people.