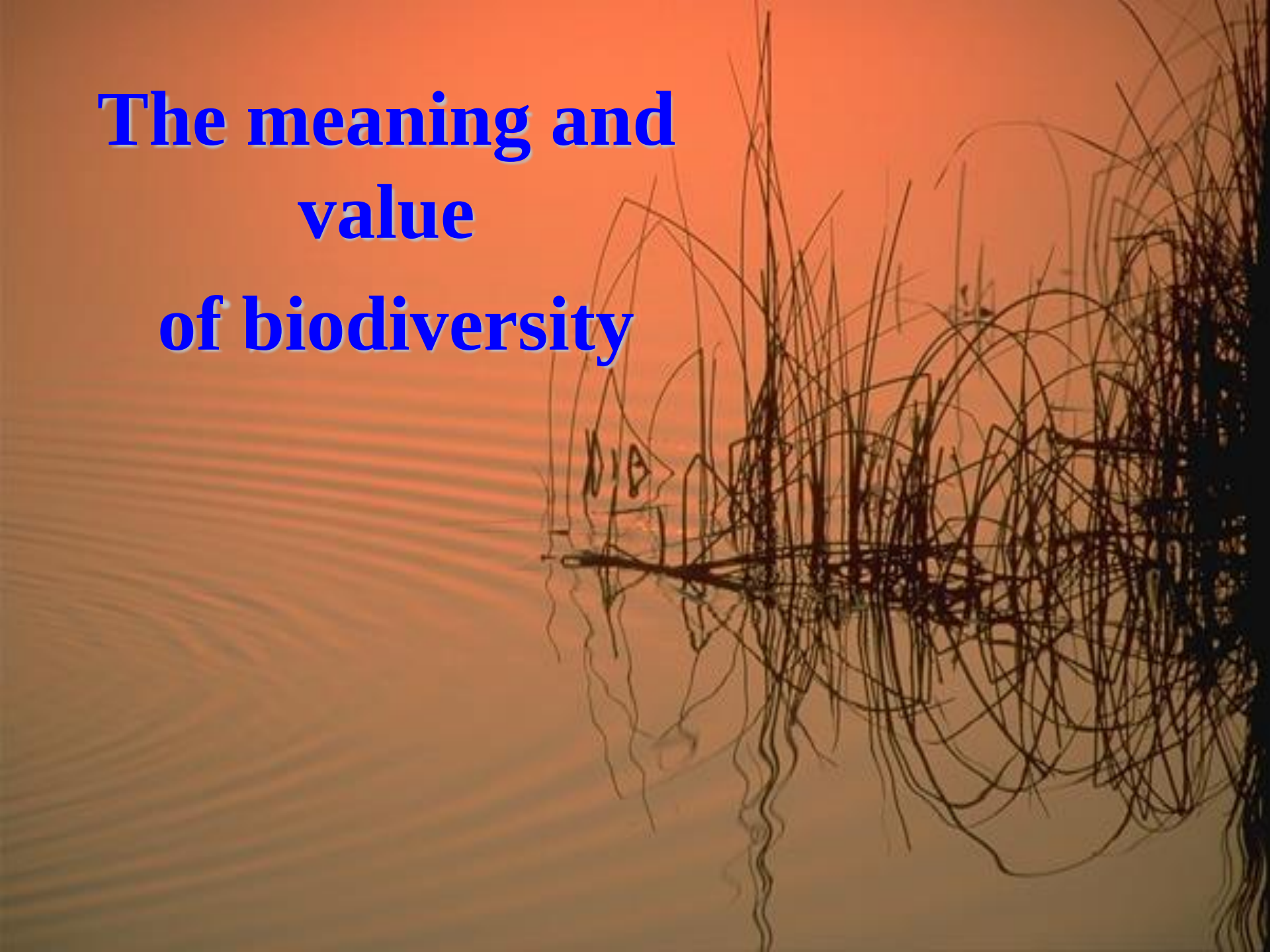
The meaning and value of biodiversity

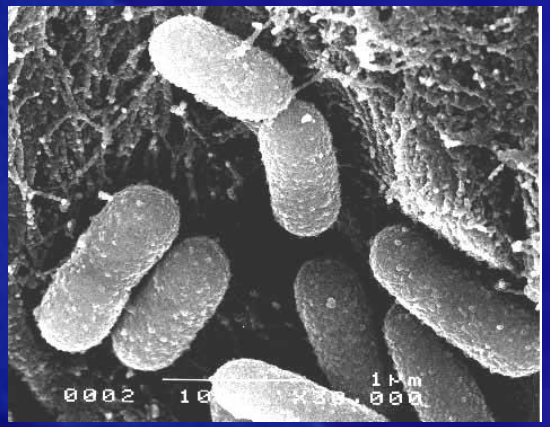


Outline

1. Biodiversity defined.
2. Values of biodiversity.
3. State of global biodiversity.

1. Biodiversity defined

Describes the number and variety of all living organisms on earth, and the range of variability exhibit by those organisms.



40,000X mag.

Giant Sequoia

Includes all forms of life on earth, from the smallest bacterium to the largest trees.

Biodiversity Defined

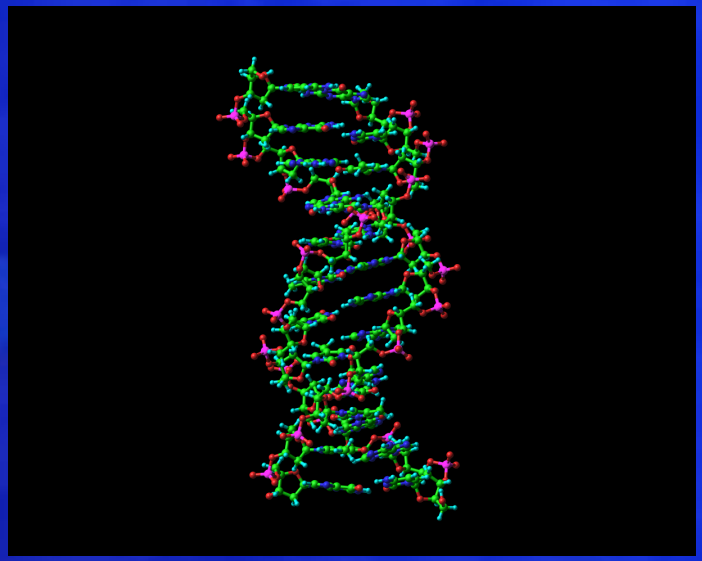
Biodiversity is defined in terms of the three basic and hierarchically related levels of biological organization:

- Genetic diversity
- Species diversity
- Ecosystem diversity

All three levels are equally important.

Genetic Diversity

Genetic diversity: the heritable variation within, and between, populations of organisms.



Genes - the smallest units of inheritance.

The Xerces Blue (*Glaucopsyche xerces*) is the most famous extinct butterfly in the USA, lost due to expanding urbanization on the San Francisco peninsula.

Species Diversity

Refers to the different kinds of plants and animals.

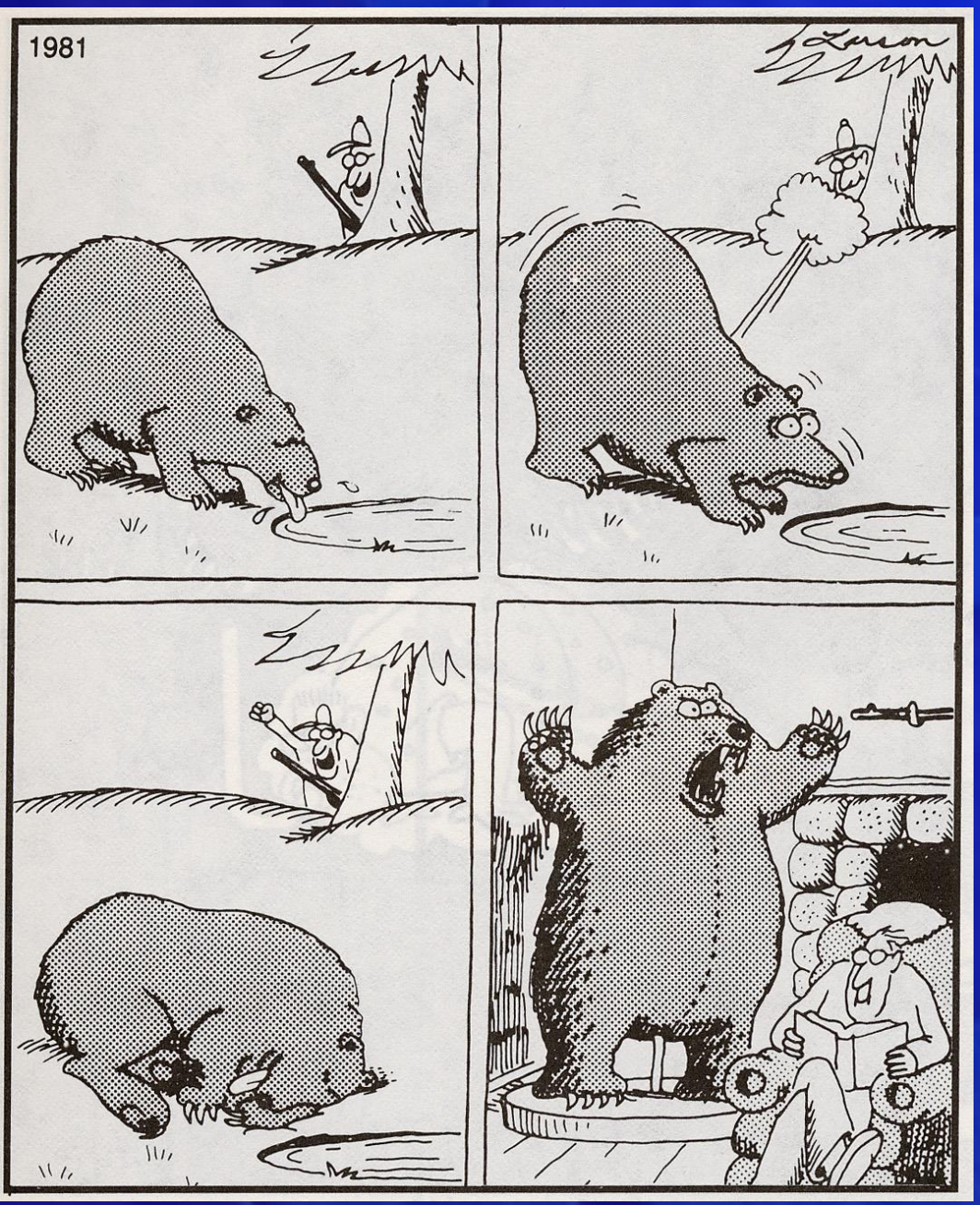
• the number of species in a site or habitat (also called species richness).

• is the most useful level of biodiversity because most scientists agree on what constitutes a species.

Ecosystem Diversity

Distinct associations of life-forms in their abiotic environment of climate, water and soil.

No unique definition and classification of ecosystems at the global level, thus it is difficult to assess ecosystem diversity other than on a local or regional basis and then, only largely in terms of vegetation.



2. Values of biodiversity.

Biodiversity Values

It is important to clearly define the reasons for believing that conservation of biodiversity is important.

Humans will not protect the things they do not value.

We must determine just what values biodiversity actually has.

Biodiversity values

1. Ecosystem integrity
2. Ecosystem services
3. Benefits to agriculture
4. Benefits to medicine
5. Benefits to industry
6. Biological control
7. Aesthetics
8. Ethical considerations
9. Warning sign
10. Future options

1. Ecosystem integrity

A car will not function correctly if parts of the engine are removed or damaged.

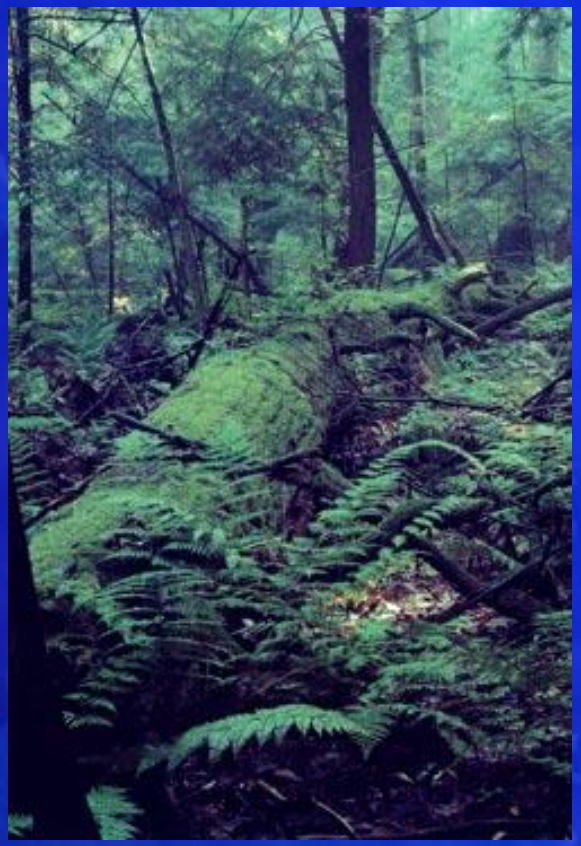
Ecosystems will not function correctly if species are removed or abiotic components are damaged.

Integrity is essential to proper function.

2. Ecosystem services

Intact ecosystems perform many beneficial services:

- atmospheric gas regulation.
- disturbance regulation.
- nutrient cycling.
- soil generation.
- regulation of water flows.
- water storage.
- water purification.



Ecosystem services (cont'd)

- erosion control.
- waste treatment.
- pollination.
- population control.
- food production.
- bioremediation.
- genetic source pool.
- recreational opportunities.
- cultural opportunities.

Ecosystem services

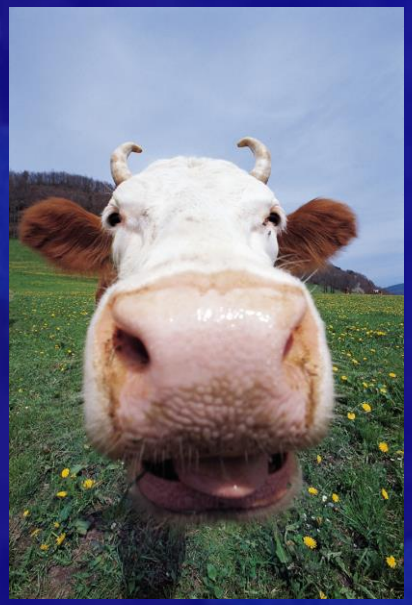
For the entire biosphere, the value of the services provided by ecological systems, and the natural capital stocks that produce them, has an estimated economic value of US$33 trillion per year.

As in … **$33,000,000,000,000**

Source: Costanza et al. Nature 387: 253. 1997

3. Benefits to agriculture

Virtually 100% of the protein from domesticated animals consumed by people comes from nine species that were formally wild: cattle, pigs, sheep, goats, water buffalo, chickens, ducks, geese and turkeys.



Benefits to agriculture

Plants

Only a very small proportion of the world's plants have been used for food on a large scale.

About 10K-50K are thought to be edible, but only about 150 are used as human food.

Benefits to agriculture

Today, 90% of the world's food comes from just 15 plant species.

Three of them - wheat, corn, and rice - supply two-thirds of this amount.

Although there are over 10,000 species of cereals, no new ones have been brought into cultivation during the past 2000 years.

Benefits to agriculture

Wild plants are also important sources of genes that can confer useful properties on our conventional crops through hybridization.

Example:

A wild relative of the potato was found in Peru, and when it was hybridized with the standard crop plant a variety was obtained that was resistant to potato blight.

4. Benefits to medicine

The potential for discovering medicinal compounds in wild organisms is enormous.

Is one of the most powerful arguments for conservation of biological diversity.

About 121 prescription drugs are derived from higher plants.

Fewer than 1% of rainforest plants have been tested for medicinal potential.

Benefits to medicine

Medicines derived from plants:

- Painkillers: morphine, codeine, quinine, atropine

- Heart stimulant: digitalis
- Malarial: quinine
- Anti-inflammatory: cortisone, prednisone
- Contraceptives; Steroids, etc, etc…….

Benefits to medicine

Anti-cancer drugs

The rosy periwinkle was used in Cuba, the Philippines, and South Africa for the treatment of inflammation, rheumatism, and diabetes. In the late 1950s, was discovered to be useful in treating childhood leukemia and Hodgkin's disease.

Benefits to medicine

The Pacific Yew tree, a rare and slow-growing tree in the Pacific Northwest, is the only source of a drug called taxol.

Is effective in treating ovarian and breast cancer.

Benefits to medicine

Antibiotics

Are generally isolated from fungi (e.g. penicillin) or bacteria (e.g. erythromycin).

However, a small group of antibiotics (mimosamycin) comes from nudibranchs (sea slugs) and a marine sponge.

5. Benefits to industry

Pesticides

Many tropical plants produce chemicals that deter herbivores.

Calabar bean was traditionally used as a poison in West Africa - developed into methyl carbamate insecticides.

Physostigma venenosum Balf.
Image processed by Thomas Schoepke
www.plant-pictures.de

Benefits to industry

Fibers

Spider silk has 5-10X the tensile strength of steel and some very unusual elastic properties. Still has not been synthetically produced.

Silkworm silk has been used for hundreds of years in production of fabrics.

Silkworm larva & pupa

Benefits to industry

Oils

About 20% of the petroleum used in North America is for plastics, fertilizers, lubricants, and adhesives. The majority of these substances can now be synthesized from plant products.

6. Biological control

Introduced animals or plants often have become serious economic pests.

Natural biological control mechanisms are more effective on alien species than broad-spectrum synthetic chemicals.

Predators – wasps, ladybugs, praying mantises

Pathogens – viruses, bacteria, fungi

7. Aesthetics

Millions of people enjoy outdoor activities: hunting, fishing, camping, wildlife watching, etc.

Nature based activities can be psychologically and emotionally restorative.

Nature has *existence value* – simply knowing that a species or landscape exists is reason enough to protect and preserve it.

"Species are worth saving for exactly the same reasons we conserve medieval cathedrals and Mozart concertos: they enrich our lives"

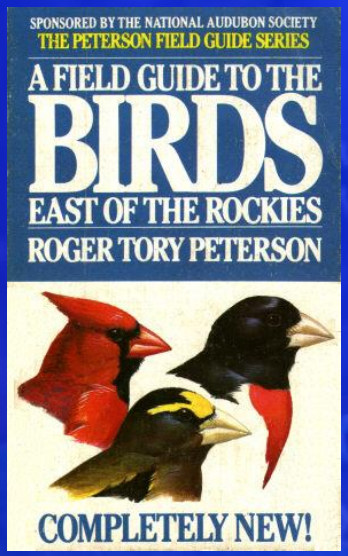
John Lawton
New Scientist, 15 August 1998

Notre Dame, Paris

Aesthetics - Ecotourism

Survey conducted in 1996 for the U.S. Fish and Wildlife Service:

- 77 million Americans participated in wildlife-related recreation.
- they spent $108 billion on eco-tourism.
- they spent only $81 billion on cars.



8. Ethical considerations

"*A thing is right when it tends to preserve the integrity, beauty, and stability of the biotic community. It is wrong when it tends otherwise.*"

Aldo Leopold

A Sand County Almanac (1949)

9. Warning sign

Coal miners used caged canaries to warn them of methane gas build-up in mine shafts.

Declining populations, anatomical abnormalities, increased morality rates, decreased productivity, lack of unpolluted regions, etc. are all signs of an unhealthy ecology.

Global ecosystems are the modern equivalent of the coal mine shaft.

10. Future Options

We cannot predict the future.

Nobody predicted that bread mold would produce important medicines (antibiotics).

Nobody predicted that a pretty flower (Periwinkles) could produce an anti-cancer drug.

Future Options

"To the electron -- may it never be of any use to anybody."

J.J. Thomson

Toast made at a scientific conference in 1898, by the discoverer of the electron.

Try to imagine a world where we do not use electrons.

Future Options

The main reason for preserving not only species but also genetic variability of both wild and domesticated species is so that we, and the other animals and plants on the planet, can…

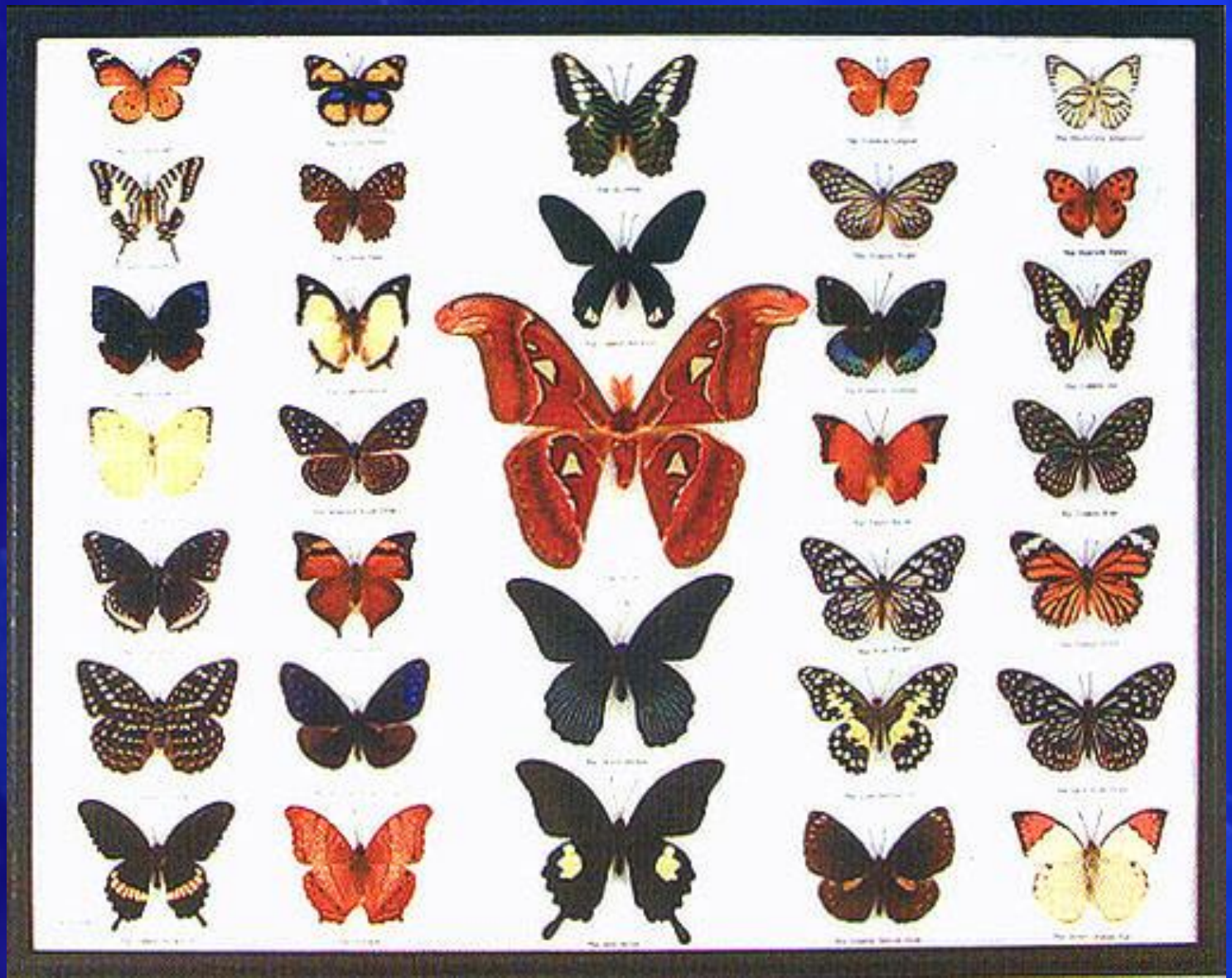
adapt to unforeseen, changing circumstances.

"Why bother to save every last species on the planet? Because they are our insurance policy."

Bob Holmes

New Scientist, 15 August 1998.

3. State of global biodiversity



Levels of Biodiversity

More than 1.4 million species of plants, animals and microorganisms have been taxonomically described.

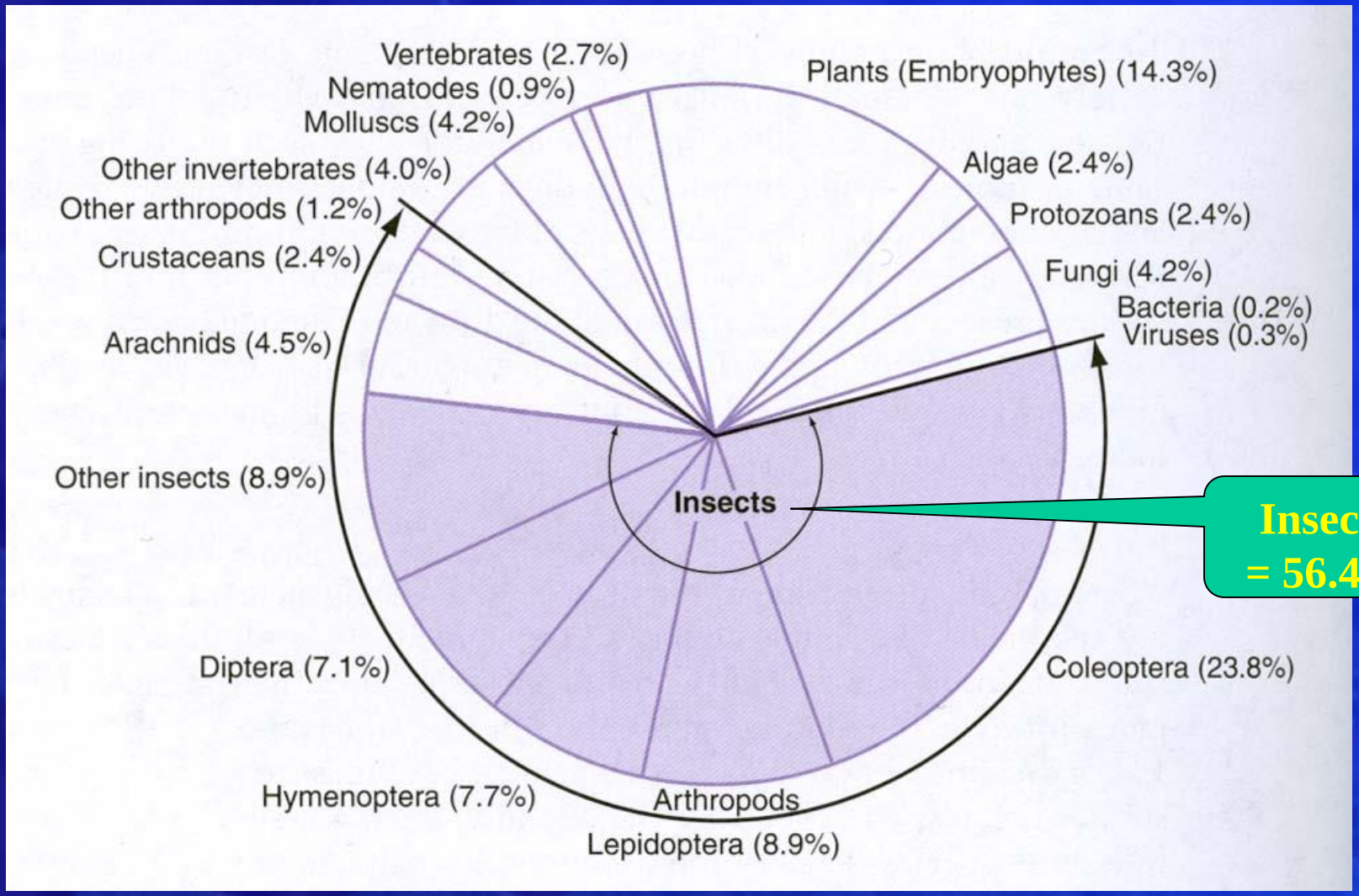
Species diversity in terrestrial and freshwater systems is greater than that found in marine systems.

TABLE 13.1 Approximate Numbers of Known Living Species by Taxonomic Group

Bacteria and cyanobacteria	5,000
Protozoa (single-celled animals)	31,000
Algae (single-celled plants)	27,000
Fungi (molds, mushrooms)	45,000
Multicellular plants	250,000
Sponges	5,000
Jellyfish, corals, anemones	10,000
Flatworms (tapeworms, flukes)	12,000
Roundworms (nematodes, hookworms)	12,000
Earthworms and leeches	12,000
Clams, snails, slugs, squids, octopuses	70,000
Insects	750,000
Mites, ticks, spiders, crabs, shrimp, centipedes, other noninsect arthropods	120,000
Starfish, sea urchins	6,000
Fish and sharks	22,000
Amphibians	4,000
Reptiles	6,000
Birds	9,000
Mammals	4,000
Total	1,400,000

Source: World Resources Institute, 1999.

Global distribution of known species (1990)



(World Conservation Monitoring Centre, 1992)

Levels of Biodiversity

Biologists have not yet surveyed and catalogued all the species on the Earth.

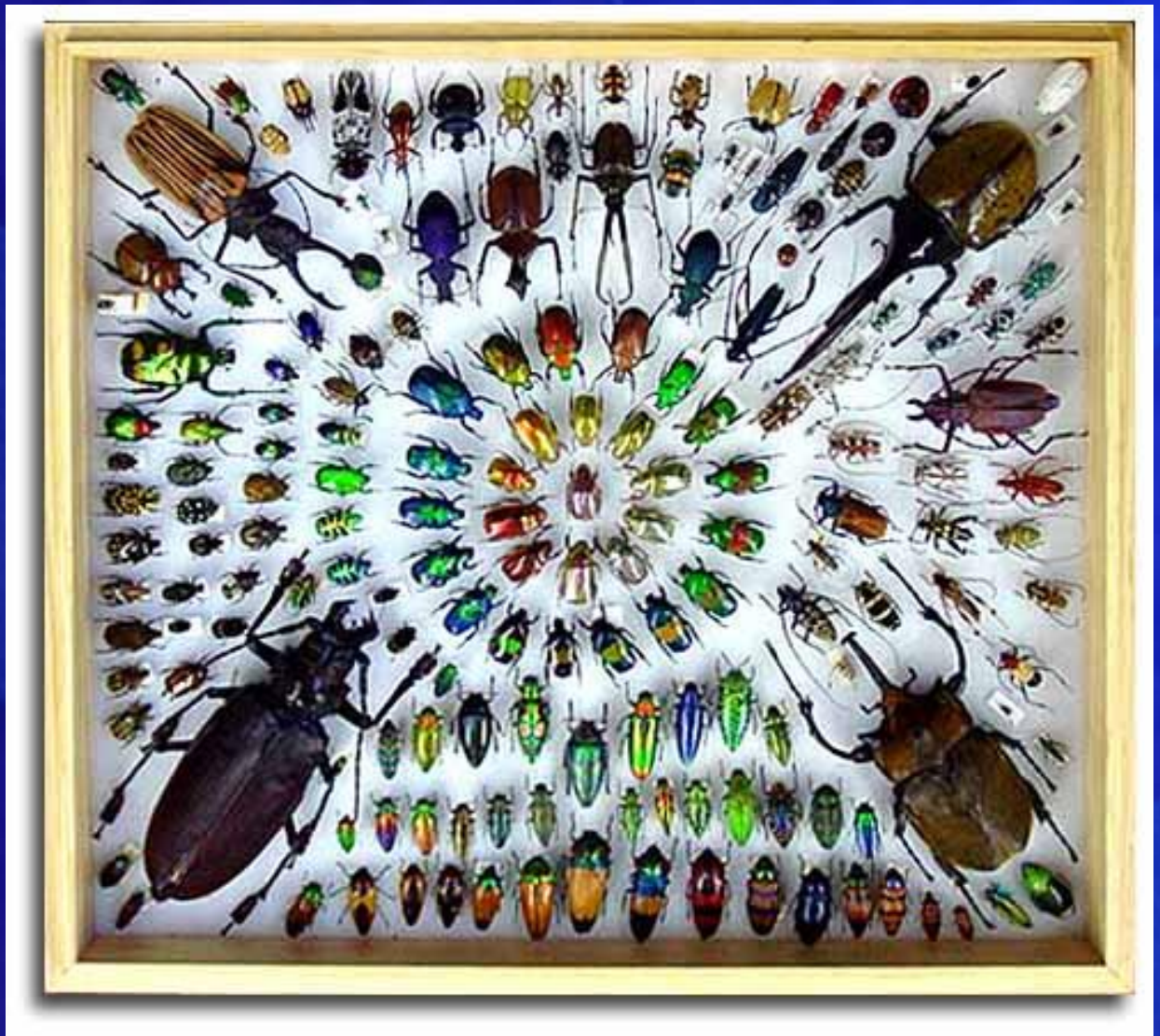
The true level of biodiversity on the planet remains poorly known. It's possible that the total number of species is closer to 10^8 than 10^7.

TABLE 14.1 Number of New Species Described per Year between 1978 and 1987 for Selected Groups of Organisms

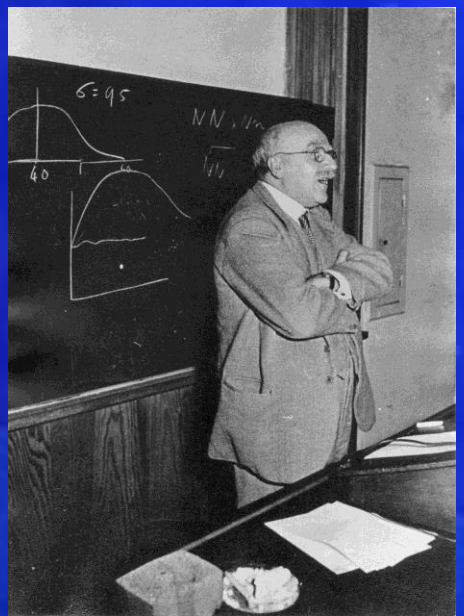
Organisms	Species Described Per Year (1978–1987)
Mammals	26
Birds	5
Amphibians and reptiles	105
Fish	231
Mollusks	366
Insects	7222
Arachnids	1250

Source: World Conservation Monitoring Center (1992).

J.B.S. Haldane, when asked what his studies of nature revealed about God:



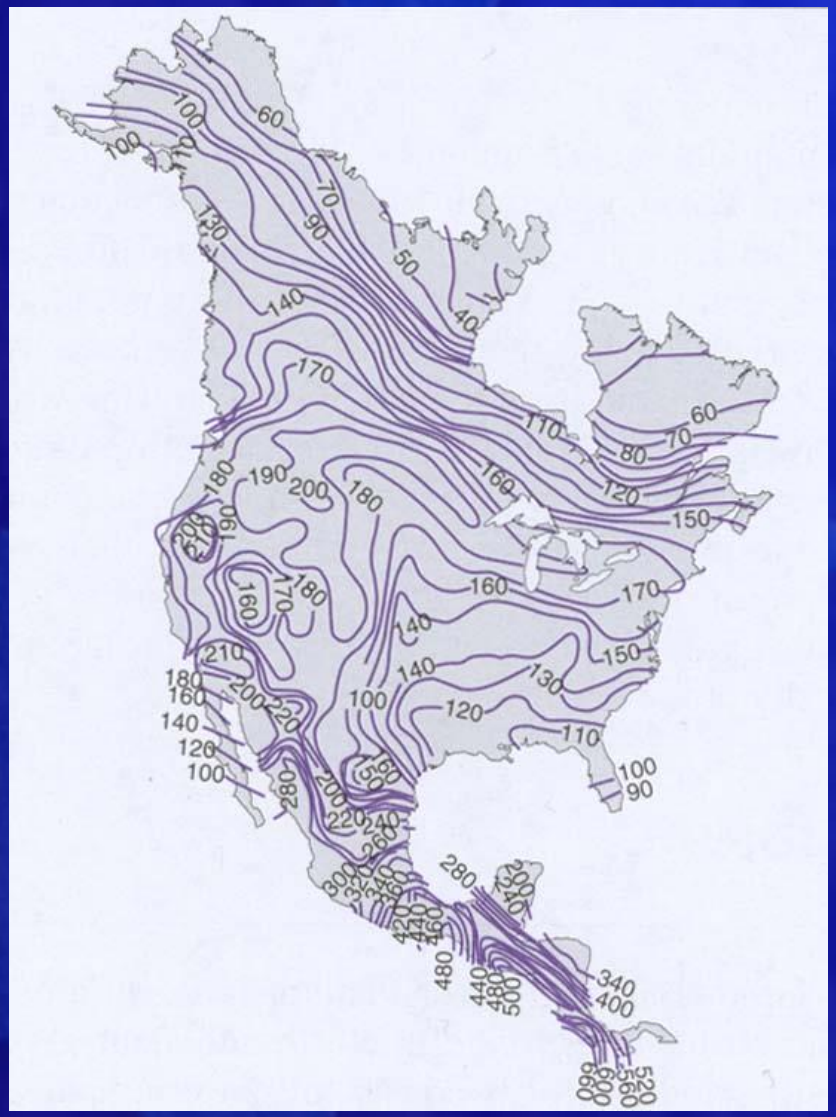
"The Creator, if He exists, has a special preference for beetles."



Latitudinal gradients

Species of butterflies:

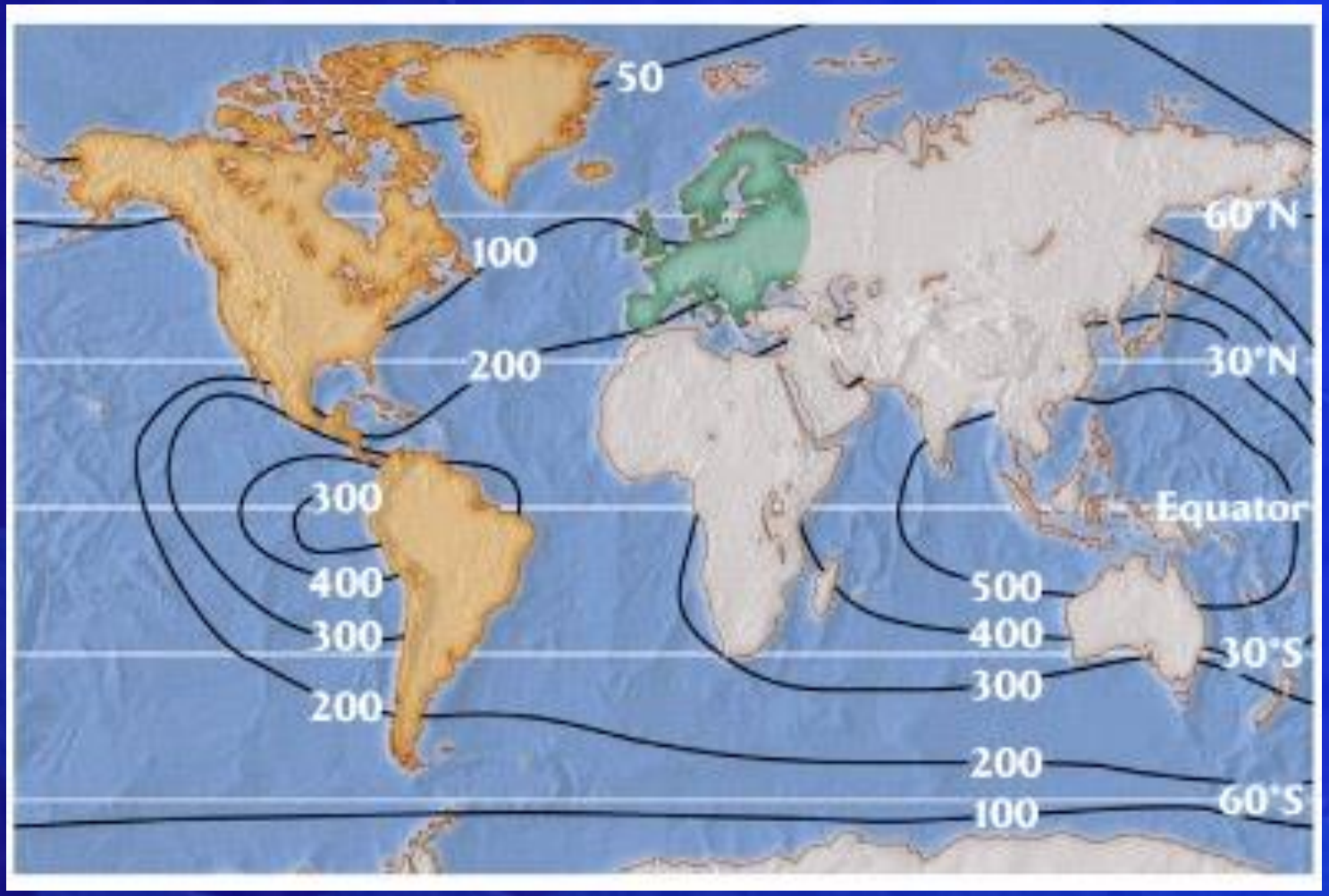
- Michigan – 134
- Panama - 1550



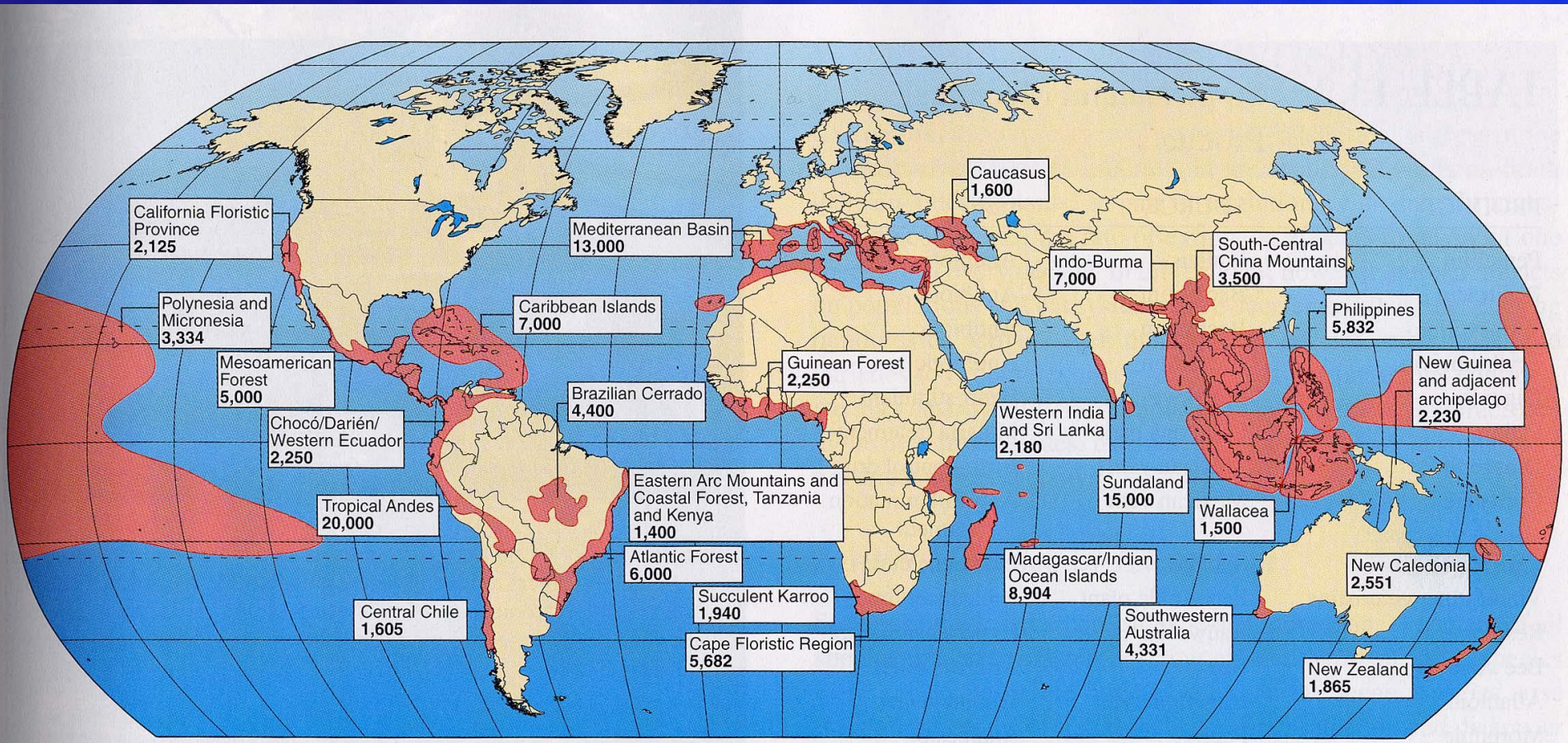
Breeding bird diversity in North America

Wood warblers of eastern Canada deciduous forest

Global bivalve diversity



Biodiversity hotspots – plant endemism



Source: Conservation International