

Chapter 5

Lecture Outline



Learning Outcomes

After studying this chapter, you should be able to answer the following questions:

- What are nine major terrestrial biomes and what environmental conditions control their distribution?
- How does vertical stratification differentiate life zones in oceans?
- Why are coral reefs, mangroves, estuaries, and wetlands biologically important?
- What do we mean by biodiversity? List several regions of high biodiversity.
- What are major benefits of biodiversity?
- What are the major human-caused threats to biodiversity?
- How can we reduce these threats to biodiversity?

*In the end, we conserve only what we love.
We will love only what we understand.
We will understand only what we are taught.*

–Baba Dioum

Forest Responses to Global Warming

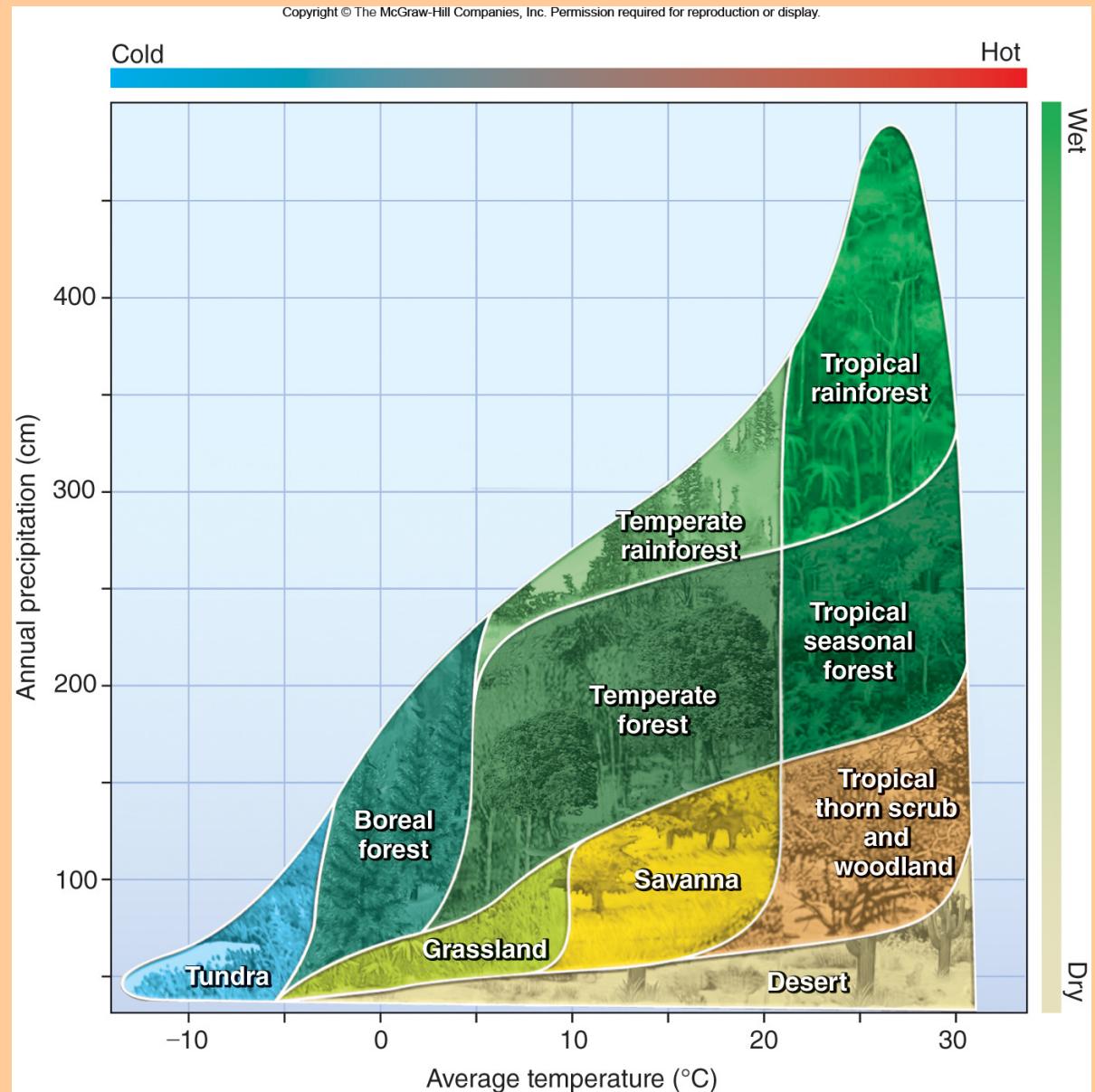
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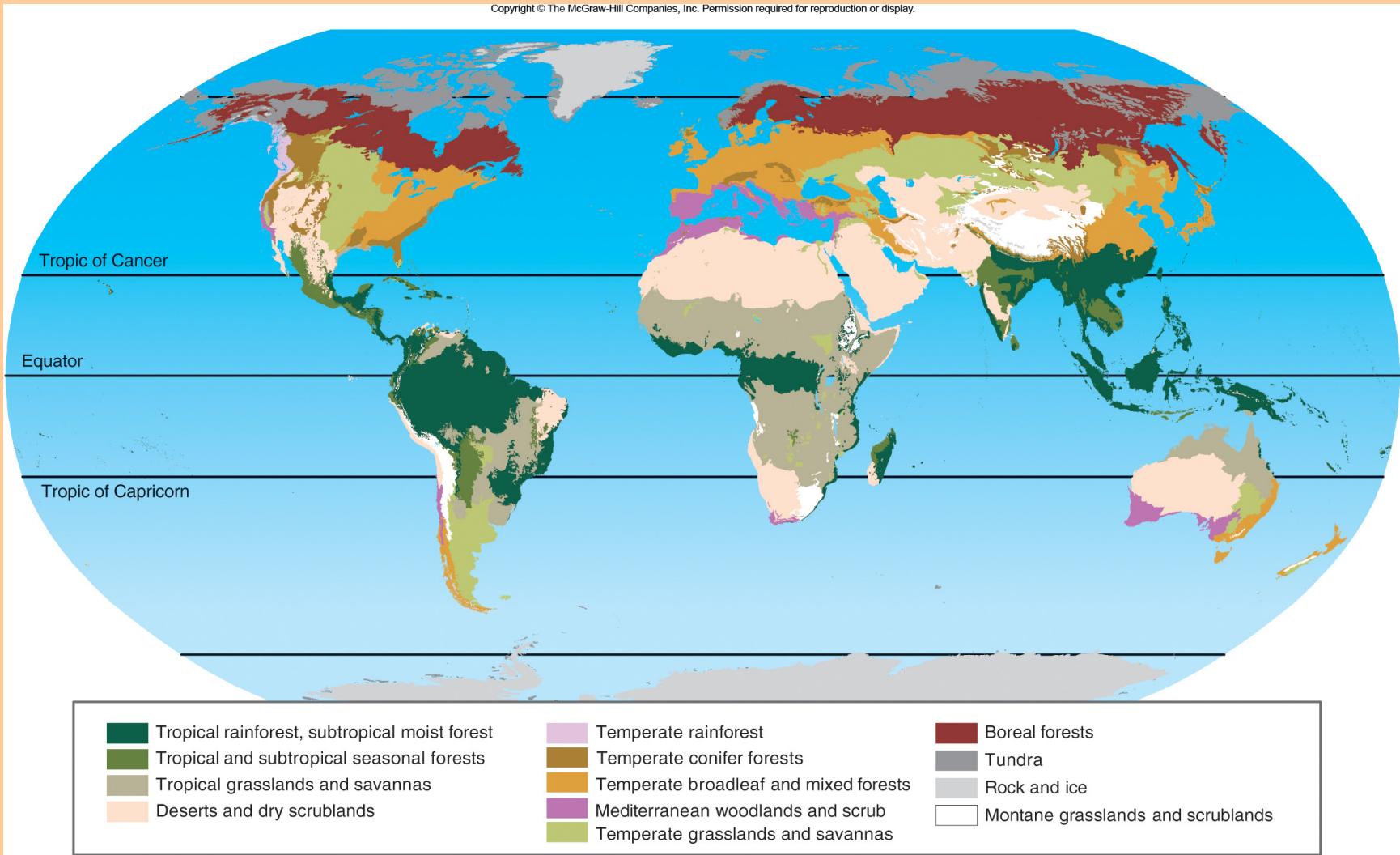
5.1 Terrestrial Biomes

- We call large biological communities **biomes**.
- If we know the range of temperature and precipitation in a particular place, we can generally predict what kind of biome is likely to occur there.
- An important characteristic of each biome is its **biodiversity**, or the number and variety of different biological species that live there.

Biome type can
be predicted
based on the
temperature and
precipitation
found in an area.



Map of Major World Biomes



Biomes Vary with Latitude

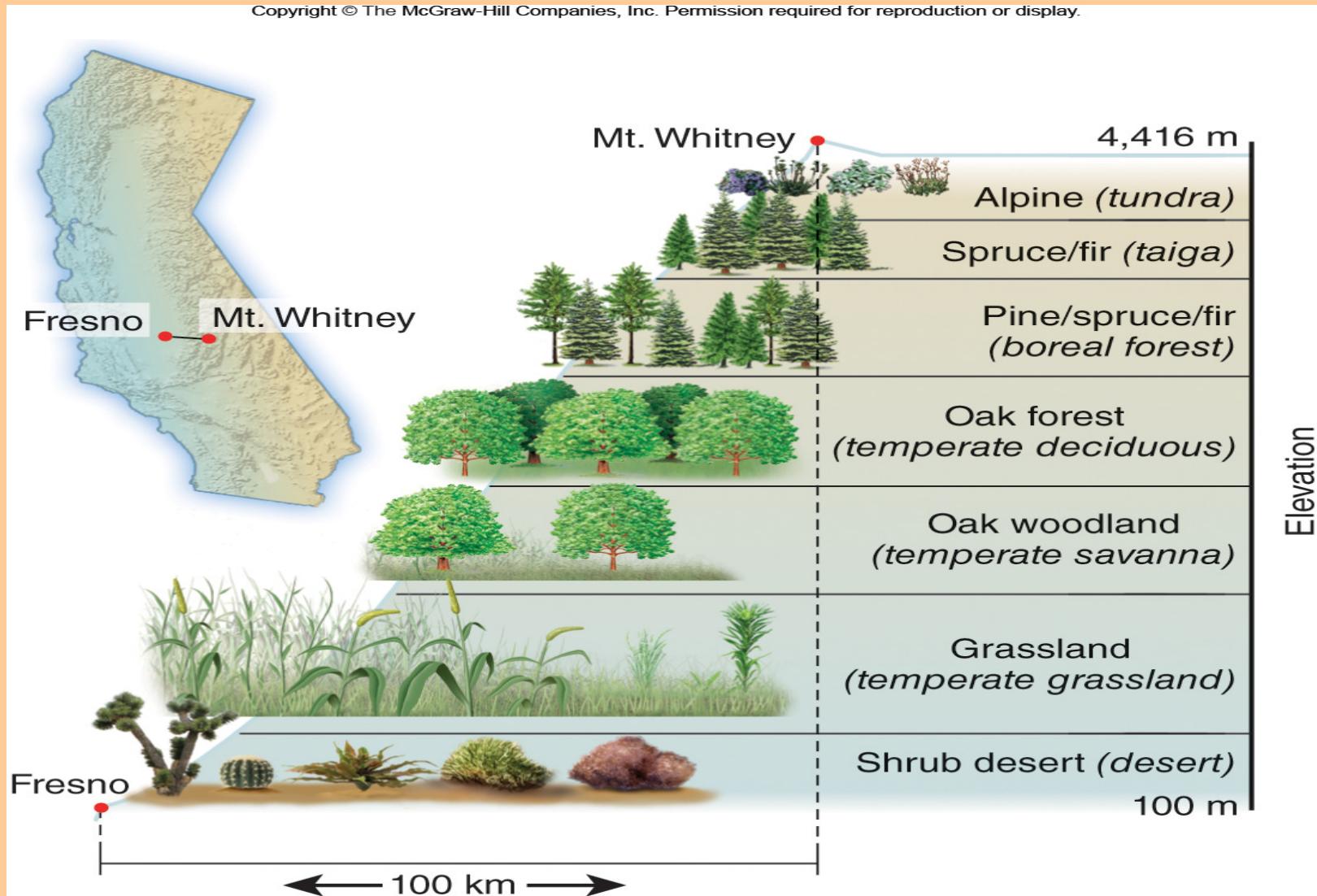
- Many temperature-controlled biomes occur in latitudinal bands.
- A band of boreal (northern) forest crosses Canada and Siberia.
- Tropical forests occur near the equator.
- Expansive grasslands lie near—or just beyond—the tropics.
- Many biomes are even named for their latitudes: like tropical rainforests or arctic tundra.

Vertical Zonation

- Temperature and precipitation change with elevation as well as with latitude.
- In mountainous regions, temperatures are cooler and precipitation is usually greater at high elevations.
- Mountains are cooler and often wetter, than low elevations.
- **Vertical zonation** is the term applied to vegetation zones which are defined by altitude.

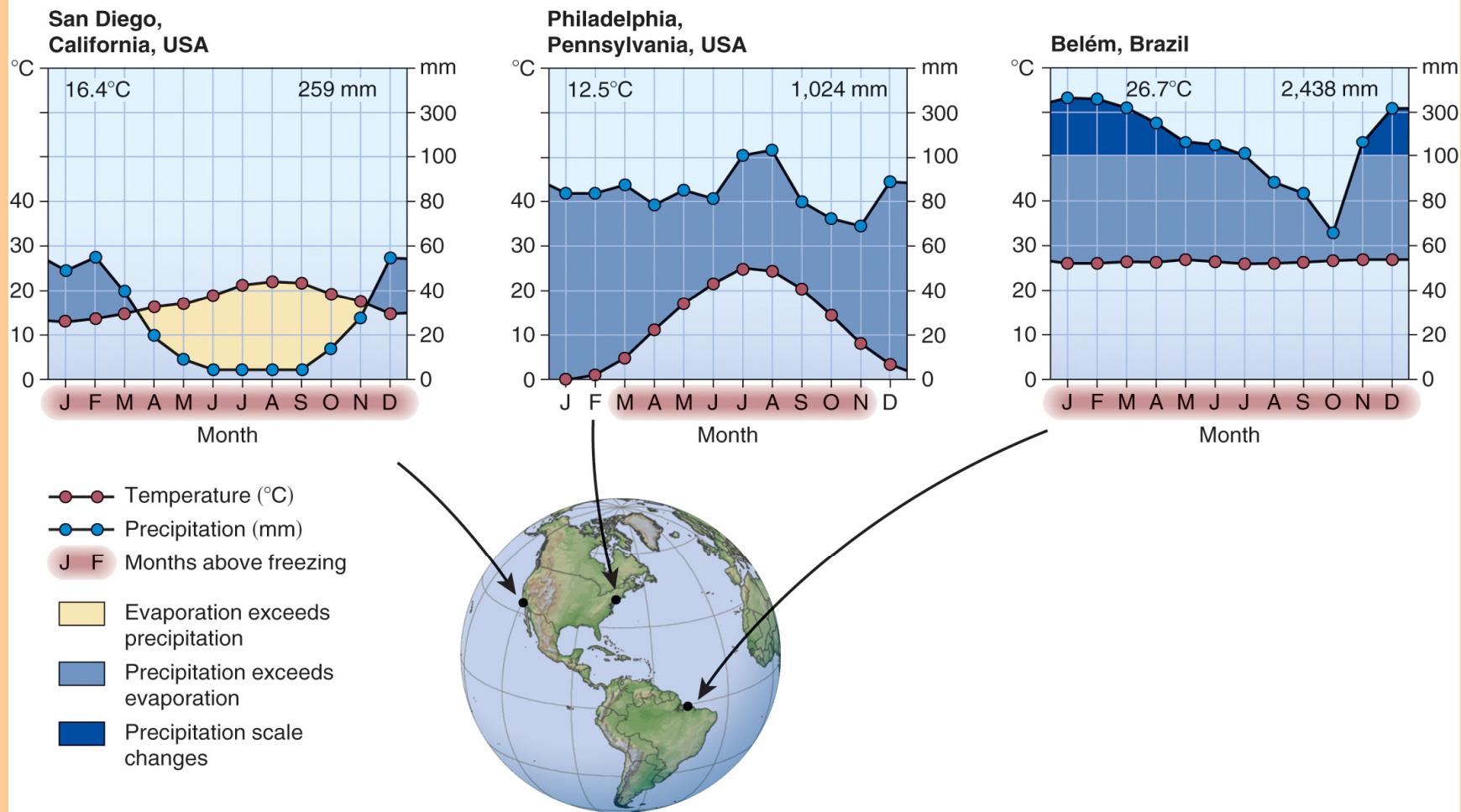
Vertical Zonation

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Annual Temperature and Precipitation Levels in Terrestrial Biomes

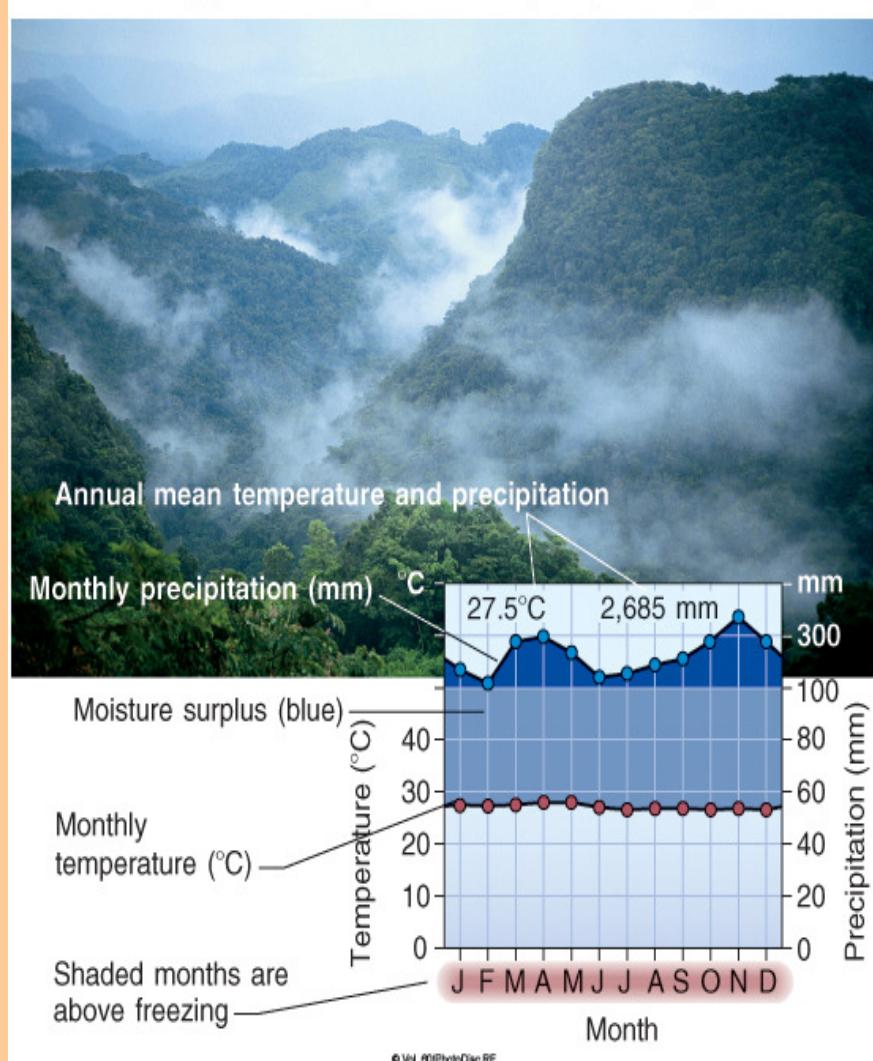
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Tropical Rainforests

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Tropical rainforests occur where rainfall is abundant—more than 200 cm (80 in.) per year—and temperatures are warm to hot year-round.

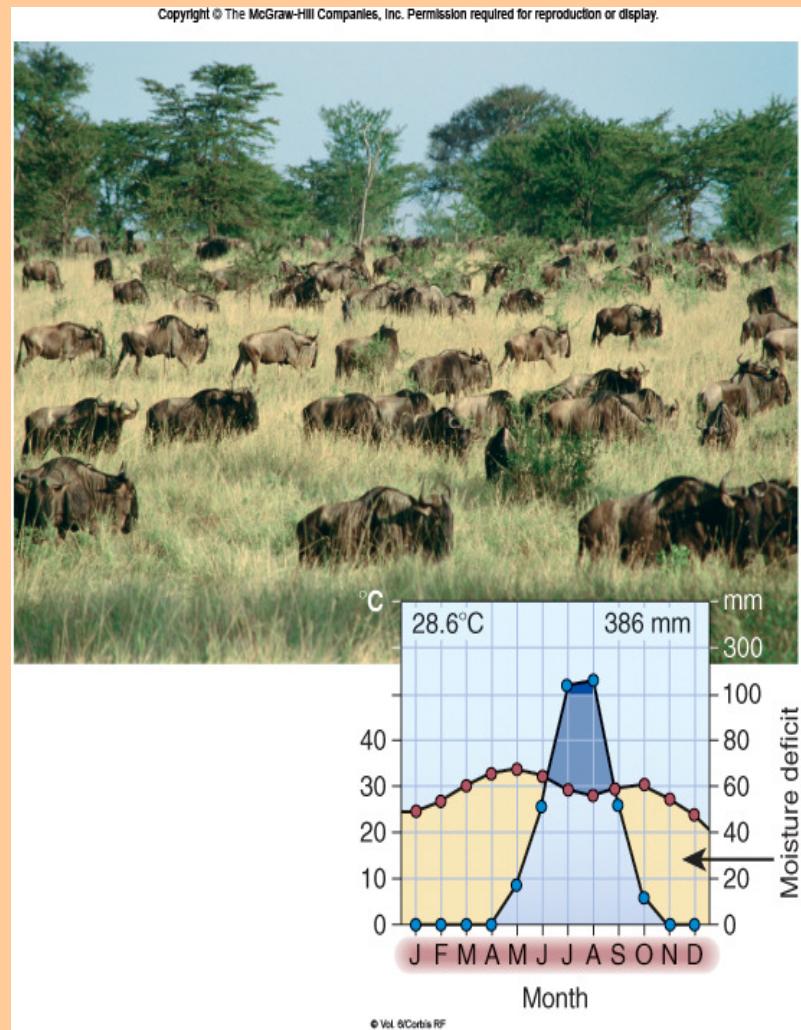


Tropical Seasonal Forest Have Annual Dry Seasons

- Many tropical regions are characterized by distinct wet and dry seasons, although temperatures remain hot year-round.
- These areas support **tropical seasonal forests**: drought-tolerant forests that look brown and dormant in the dry season but burst into vivid green during rainy months.
- These forests are often called dry tropical forests because they are dry much of the year.

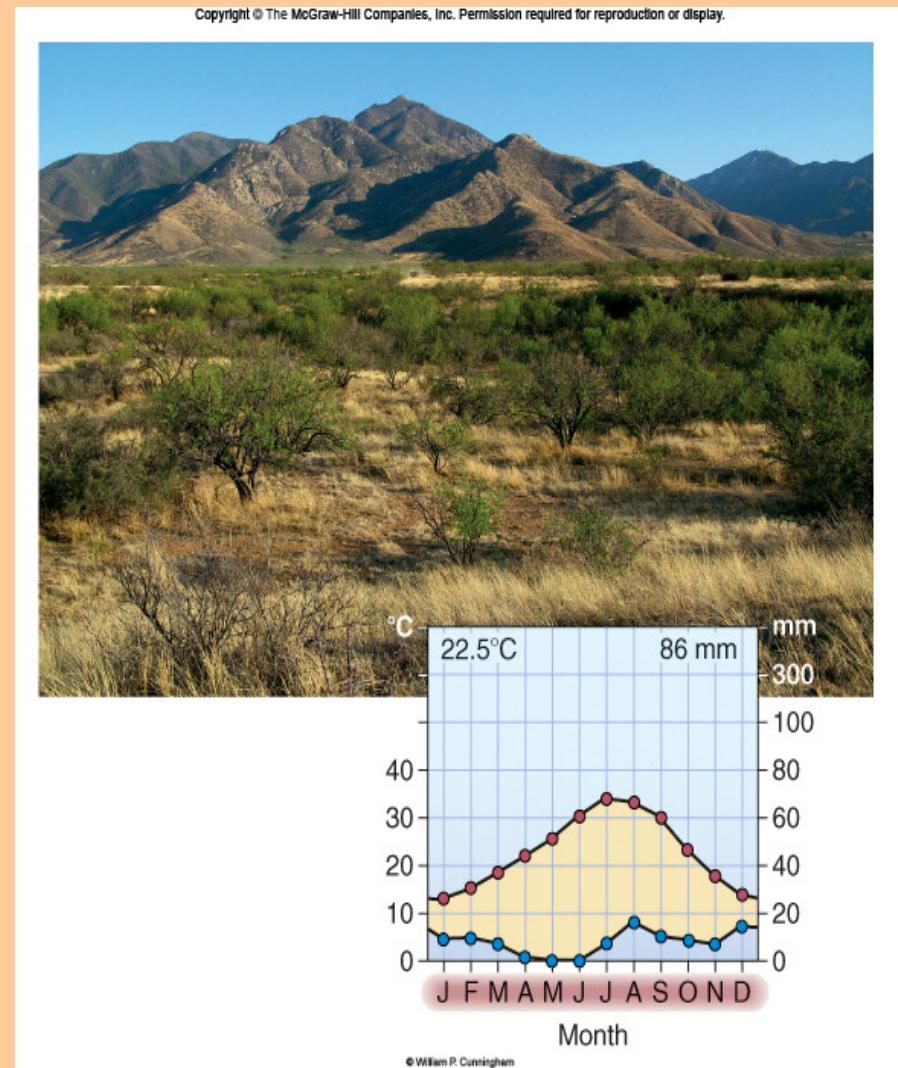
Tropical Savannas and Grasslands are Dry Most of the Year

Where there is too little rainfall to support forests, we find open **grasslands** or grasslands with sparse tree cover, which we call **savannas**.



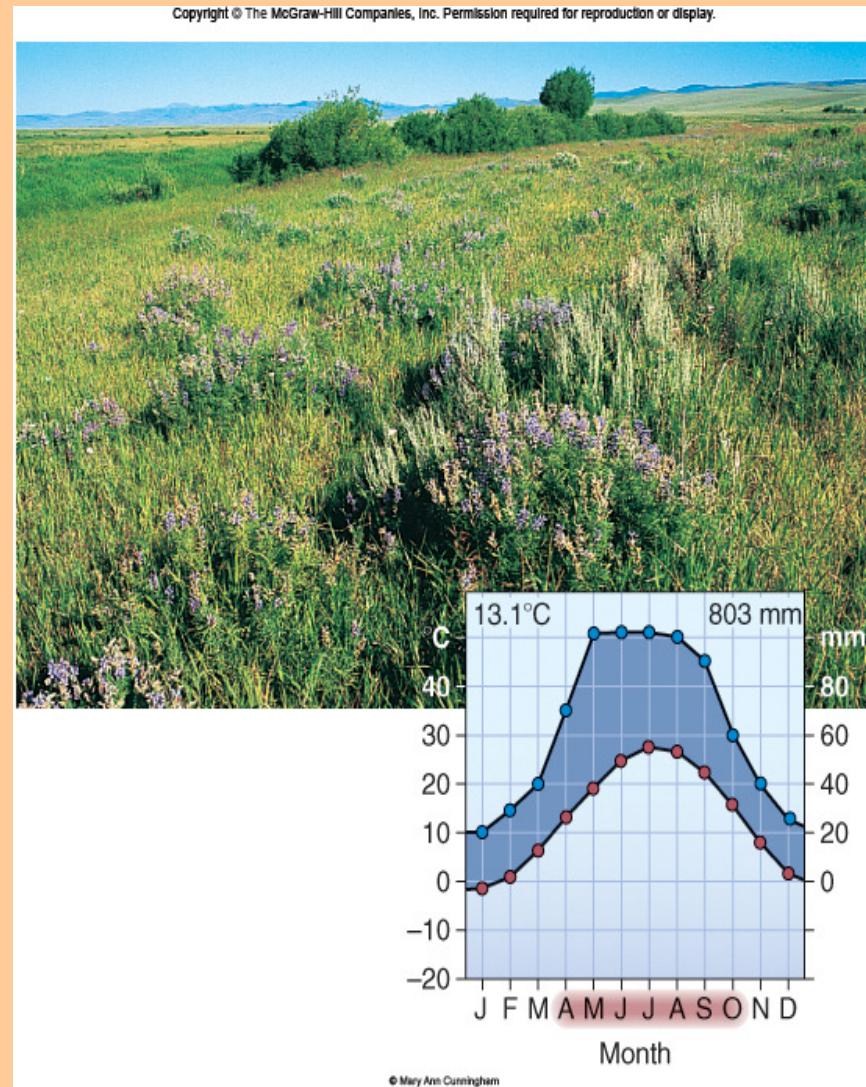
Deserts are Hot or Cold, but Always Dry

Deserts occur where precipitation is uncommon and slight, usually with less than 30 cm of rain per year.



Temperate Grasslands have Rich Soils

As in tropical latitudes, **temperate (midlatitude) grasslands** occur where there is enough rain to support abundant grass but not enough for forests.

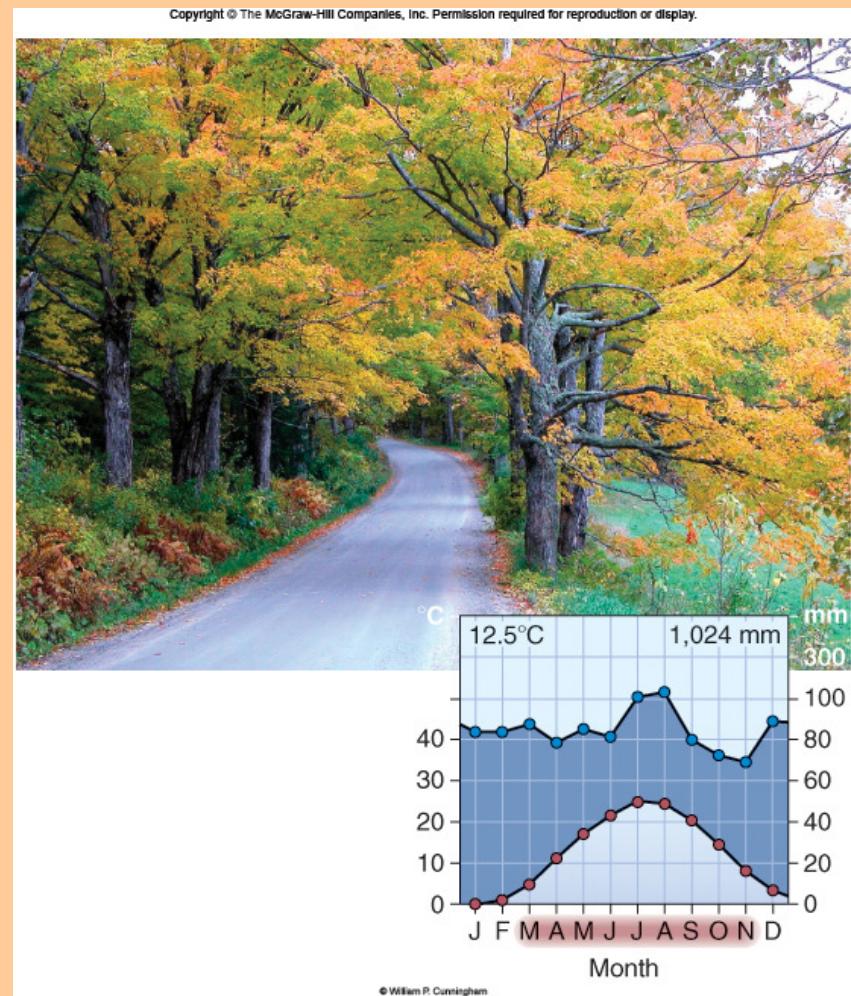


Temperate Scrublands Have Summer Drought

- Often, dry environments support drought-adapted shrubs and trees, as well as grass. These mixed environments can be highly variable. They can also be very rich biologically.
- Such conditions are often described as **mediterranean scrub** or in California, **chaparral**.
- Evergreen shrubs with small, leathery leaves form dense thickets. Scrub oaks, drought-resistant pines, or other small trees often cluster in sheltered valleys.

Temperate Forests can be Evergreen or Deciduous

These forests are grouped by tree type, broad-leaved **deciduous** (losing leaves seasonally) or evergreen **coniferous** (cone-bearing).



Deciduous Forests

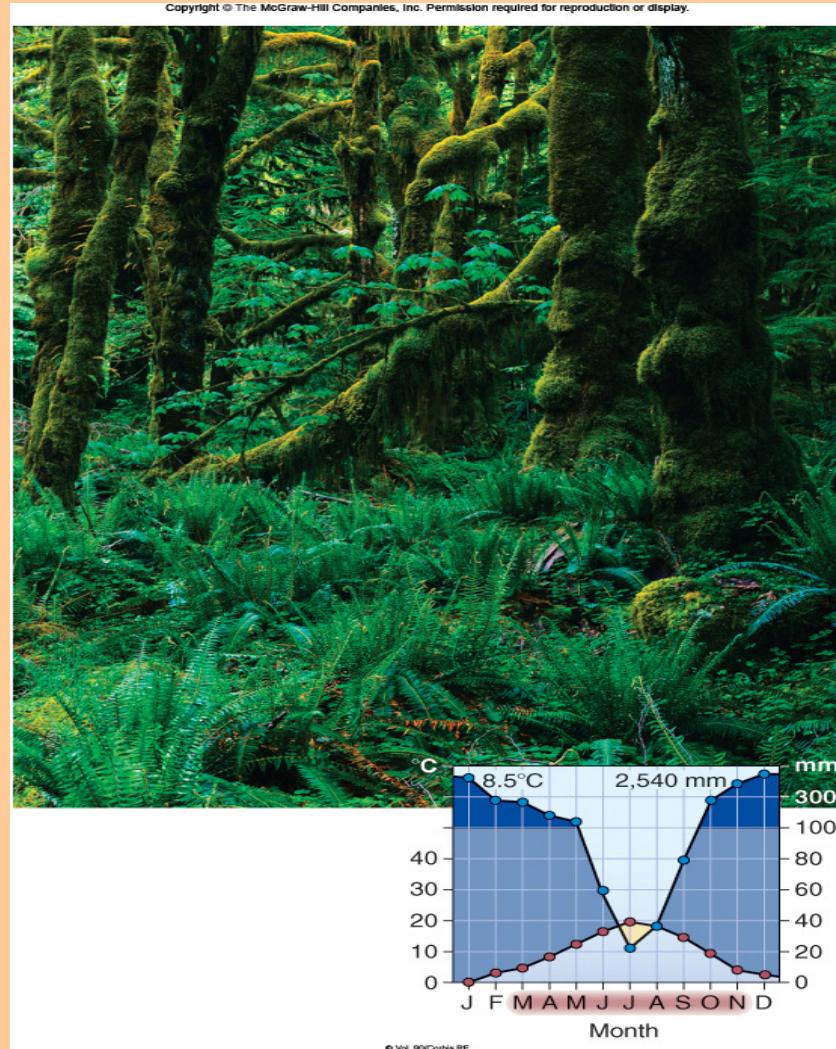
- Broad-leaf forests occur throughout the world where rainfall is plentiful. In mid-latitudes, these forests are deciduous and lose their leaves in winter.
- The loss of green chlorophyll pigments can produce brilliant colors in these forests in autumn.
- At lower latitudes, broad-leaf forests may be evergreen or drought-deciduous. Southern live oaks, for example, are broad-leaf evergreen trees.

Coniferous Forests

- Coniferous forests grow in a wide range of environmental conditions.
- Often they occur where moisture is limited: in cold climates, moisture is unavailable (frozen) in winter; hot climates may have seasonal drought sandy soils hold little moisture, and they are often occupied by conifers.
- Thin, waxy leaves (needles) help these trees reduce moisture loss.

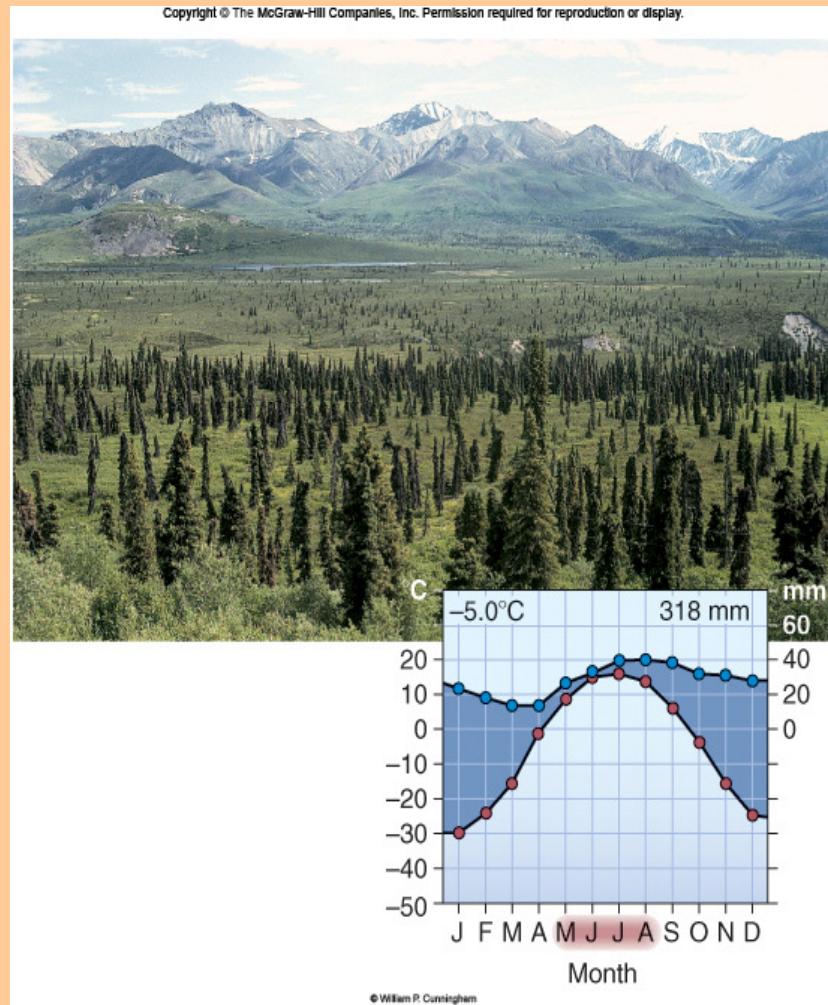
Temperate Rainforests

The coniferous forests of the Pacific coast grow in extremely wet conditions. The wettest coastal forests are known as **temperate rainforest**, a cool, rainy forest often enshrouded in fog.



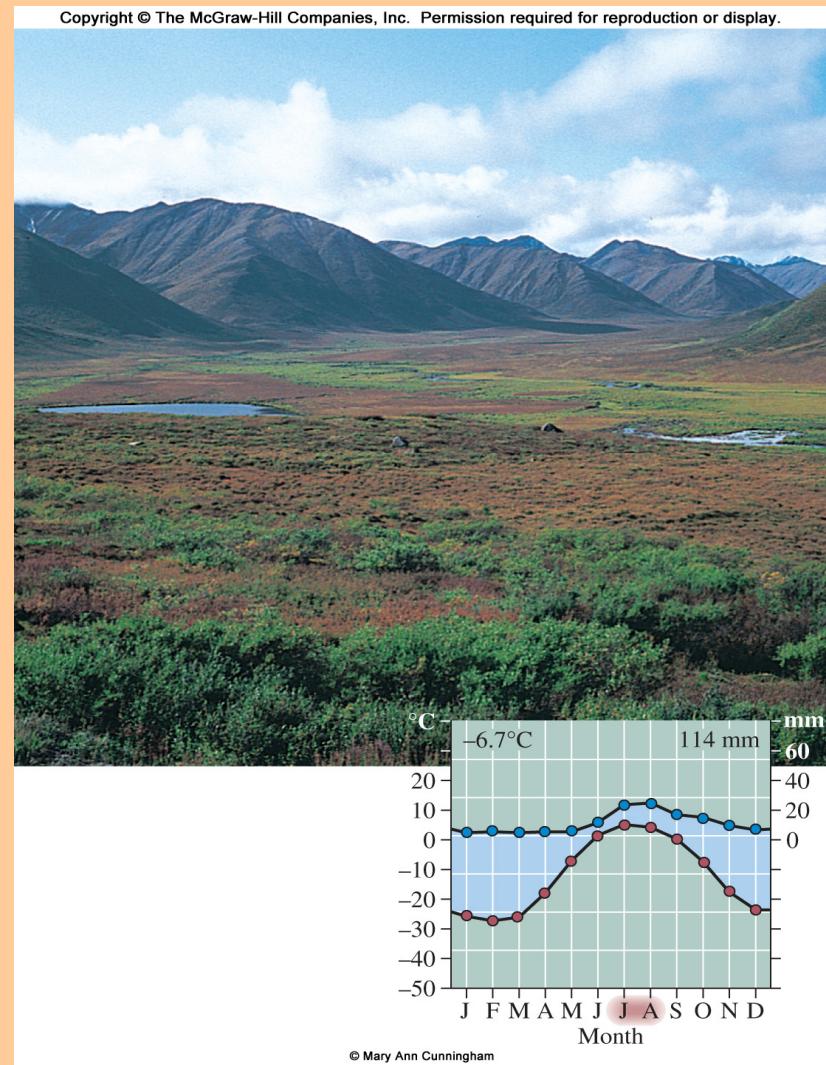
Boreal Forests Lie North of the Temperate Zone

- Because conifers can survive winter cold, they tend to dominate the **boreal forest**.
- Dominant trees are pines, hemlocks, spruce, cedar, and fir.
- Boreal forests are found in Siberia, Canada, and the western United States.



Tundra Can Freeze in Any Month

- Tundra is a treeless landscape where temperatures are below freezing most of the year.
- It occurs at high latitudes or on mountaintops, has a growing season of only two to three months.

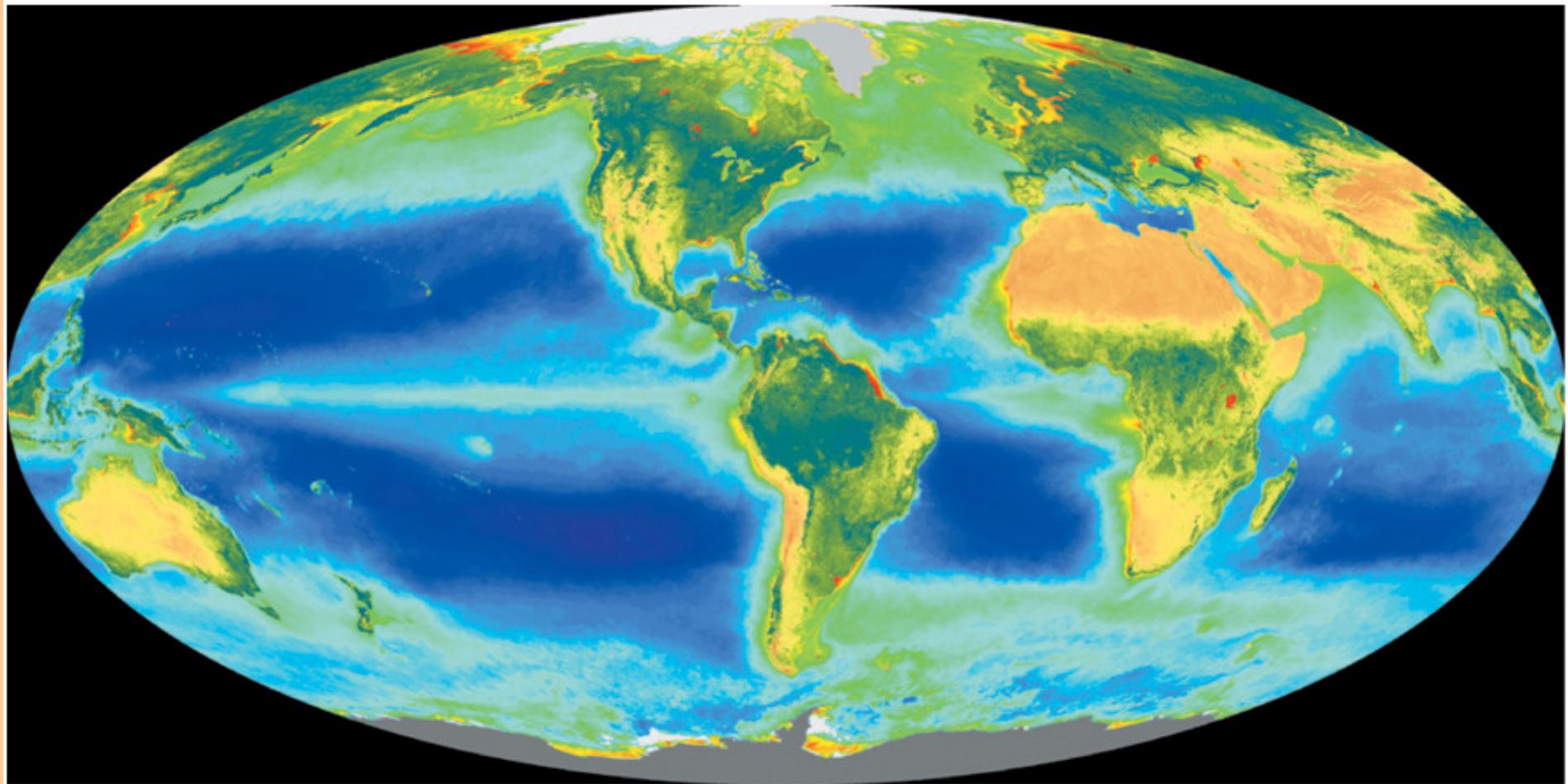


5.2 Marine Ecosystems

- Most marine communities depend on photosynthetic organisms.
- **Phytoplankton:** tiny, free-floating photosynthetic algae often support a marine food web rather than trees or grasses.
- In oceans, photosynthetic activity tends to be greatest near coastlines, where nitrogen, phosphorus, and other nutrients wash offshore and fertilize primary producers.

Satellite Measurements of Primary Productivity in the Oceans

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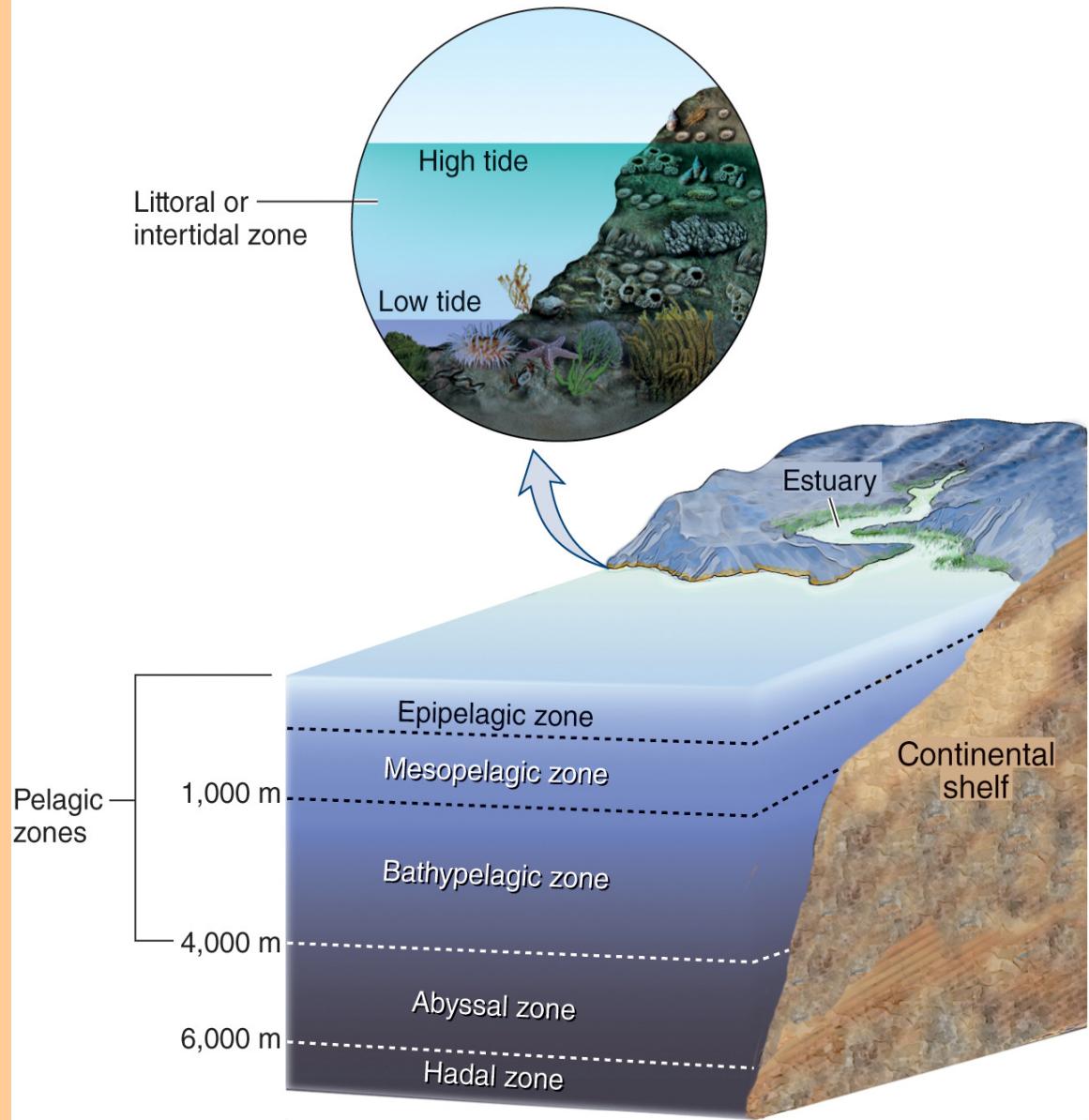


Open Ocean Communities Vary from Surface to Hadal Zone

- Ocean systems can be described by depth and proximity to shore:
 - **Benthic** communities occur on the bottom.
 - **Pelagic** zones are the water column.
- The **epipelagic zone** has photosynthetic organisms.
- Below are the **mesopelagic** and **bathypelagic zones**.
- The deepest layers are the **abyssal zone** (to 4,000 m) and **hadal zone** (deeper than 6,000 m).
- Shorelines are known as **littoral zones**, and the area exposed by low tides is known as the **intertidal zone**.

Vertical Stratification is a Key Feature of Aquatic Ecosystems

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Deep-sea Thermal Vent Communities

- Deep-sea thermal vent communities are another remarkable type of marine system.
- These communities are based on microbes that capture sulfur compounds released from thermal vents on the ocean floor.



Tidal Shores Support Rich, Diverse Communities



Coral reefs are among the best-known marine systems, because of their extraordinary biological productivity and their diverse and beautiful organisms.

Tidal Shores Continued: Mangroves

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(b) Mangroves

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Mangroves are a diverse group of salt-tolerant trees that grow along warm, calm marine coasts around the world.

Tidal Shores Continued: Estuaries & Salt Marshes

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(c) Estuary and salt marsh

© Andrew Martinez/Photo Researchers

Estuaries are bays where rivers empty into the sea, mixing fresh water with salt water. **Salt marshes**, shallow wetlands flooded regularly or occasionally with seawater, occur on shallow coastlines, including estuaries.

Tidal Shores Continued: Tide Pools

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(d) Tide pool

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Tide pools are depressions in a rocky shoreline that are flooded at high tide, but retain some water at low tide.

5.3 Freshwater Ecosystems

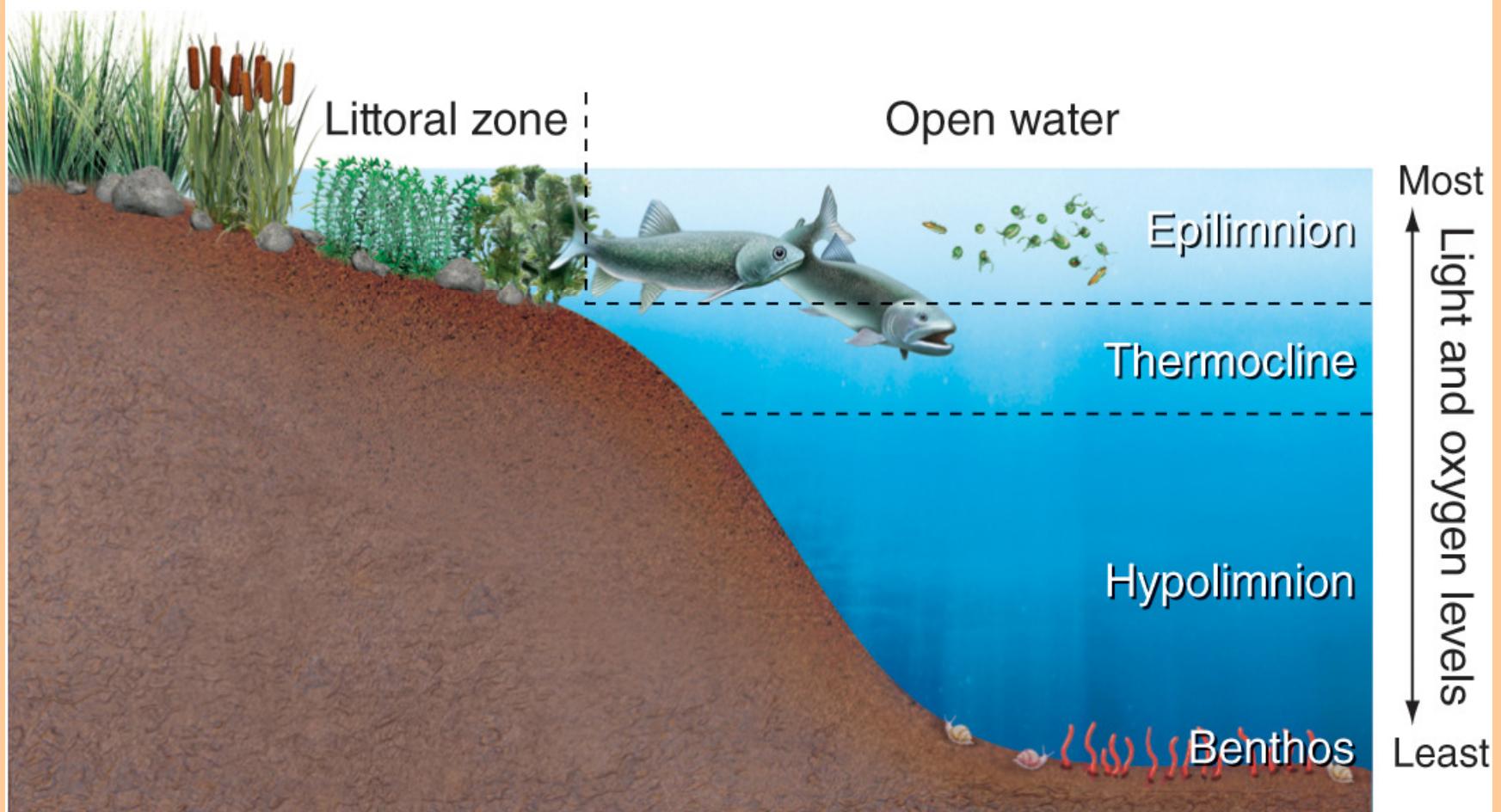
- Freshwater environments are far less extensive than marine environments, but they are centers of biodiversity.
- Most terrestrial communities rely, to some extent, on freshwater environments.
- In deserts, isolated pools, streams, and even underground water systems support astonishing biodiversity as well as provide water to land animals.

Lakes Have Extensive Open Water

- Freshwater lakes, like marine environments, have distinct vertical zones.
- Near the surface is a subcommunity of plankton, mainly microscopic plants, animals, and protists.
- Fish move through the water column, sometimes near the surface and sometimes at depth.
- Finally, the bottom, or *benthos*, is occupied by a variety of snails, burrowing worms, fish, and other organisms

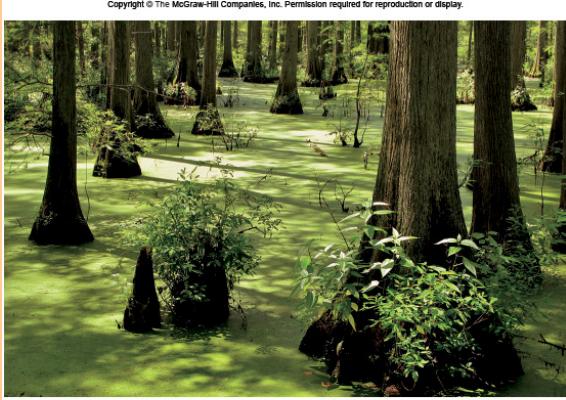
Layers of a Deep Lake

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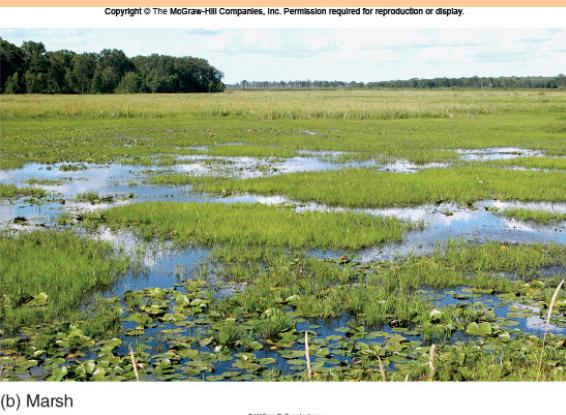


Wetlands are Shallow and Productive

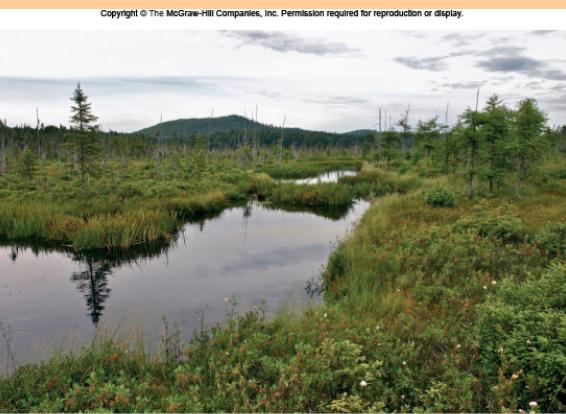
- Wetlands are shallow ecosystems in which the land surface is saturated or submerged at least part of the year.
- Wetlands have vegetation that is adapted to grow under saturated conditions.
- These relatively small systems support rich biodiversity and are essential for both breeding and migrating birds.
- As water stands in wetlands, it also seeps into the ground, replenishing groundwater supplies.



(a) Swamp, or wooded wetland
© William P. Cunningham



(b) Marsh
© William P. Cunningham



(c) Bog
© Mary Ann Cunningham

Wetlands are Described by Their Vegetation

- **Swamps** are wetlands with trees.
- **Marshes** are wetlands without trees.
- **Bogs** are areas of water-saturated ground usually composed of deep layers of undecayed vegetation known as peat.

Streams and Rivers are Open Systems

- Streams form wherever precipitation exceeds evaporation and surplus water drains from the land.
- As streams collect water and merge, they form rivers. Ecologists consider a river system to be a continuum of constantly changing environmental conditions and community inhabitants from the headwaters to the mouth of a drainage or watershed.

5.4 Biodiversity

- **Biodiversity**, the variety of living things.
- Three kinds of biodiversity are essential to preserve ecological systems and functions:
 - **genetic diversity** is a measure of the variety of versions of the same genes within individual species.
 - **species diversity** describes the number of different kinds of organisms within a community or ecosystem.
 - **ecological diversity** refers to the richness and complexity of a biological community.

Insects and Invertebrates Make Up Half of All Known Species

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Biodiversity Hot Spots are Rich and Threatened

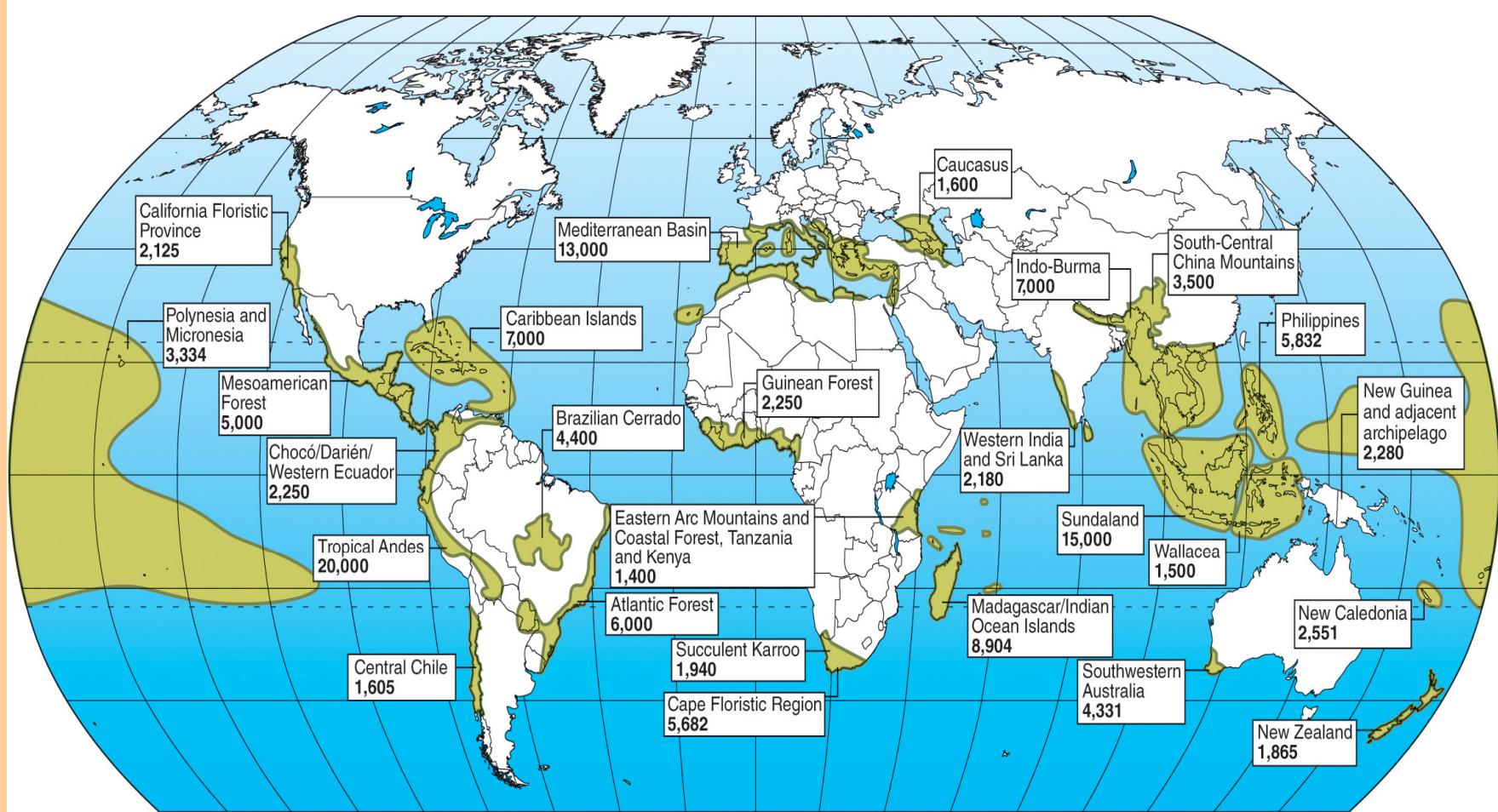
- Most of the world's biodiversity concentrations are near the equator, especially tropical rainforests and coral reefs.
- Of all the world's species, only 10 to 15 percent live in North America and Europe. Many of the organisms in megadiversity countries have never been studied by scientists.
- Areas isolated by water, deserts, or mountains can also have high concentrations of unique species and biodiversity.

5.5 Benefits of Biodiversity

- We benefit from other organisms in many ways, some of which we don't appreciate until a particular species or community disappears.
- Even seemingly obscure and insignificant organisms can play irreplaceable roles in ecological systems or be the source of genes or drugs that someday may be indispensable.

Map of Biodiversity Hot Spots

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Biodiversity Provides Food and Medicines

- Wild plant species could make important contributions to human food supplies. Genetic material from wild plants has been used to improve domestic crops.
- Wild bees, moths, bats, and other organisms provide pollination for most of the world's agricultural crops.
- Pharmaceutical products derived from developing world plants, animals, and microbes bring in more than \$30 billion per year.

Biodiversity Can Aid Ecosystem Stability

- High diversity may help biological communities withstand environmental stress better and recover more quickly than those with fewer species.
- Because we don't fully understand the complex interrelationships between organisms, we often are surprised and dismayed at the effects of removing seemingly insignificant members of biological communities.
- Maintaining biodiversity is essential to preserving ecological services.

Aesthetic and Existence Values are Important

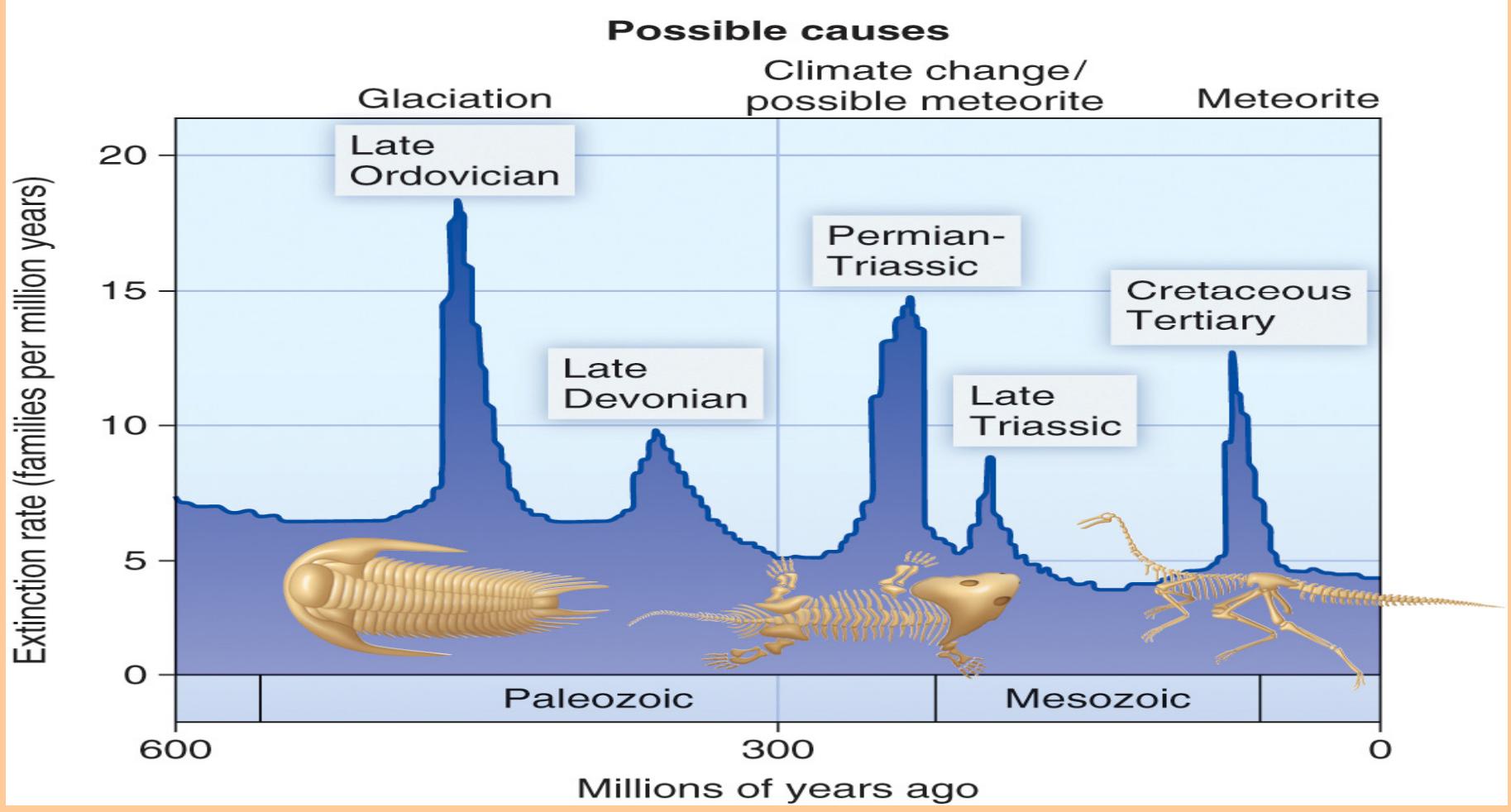
- Nature appreciation is economically important. The U.S. Fish and Wildlife Service estimates that Americans spend \$104 billion every year on wildlife-related recreation. This is 25 percent more than the \$81 billion spent each year on new automobiles.
- For many people, just the idea that wildlife exists has value. This idea is termed **existence value**. Even if they will never see a tiger or a blue whale, many find it gratifying to know they exist.

5.6 What Threatens Biodiversity?

- **Extinction**, the elimination of a species, is a normal process of the natural world; however, human impacts have accelerated that rate recently.
- In geologic history, extinctions are common. Studies of the fossil record suggest that more than 99 percent of all species that ever existed are now extinct.
- Most of those species were gone long before humans came on the scene.
- Periodically, mass extinctions have wiped out vast numbers of species and even whole families

Major Mass Extinctions Through Geological History

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HIPPO Summarizes Human Impacts

- Between A.D. 1600 and 1850, human activities appear to have eliminated two or three species per decade.
- In the past 150 years the extinction rate has increased to thousands per decade.
- E. O. Wilson summarizes human threats to biodiversity with the acronym **HIPPO**, which stands for *Habitat destruction, Invasive species, Pollution, Population of humans, and Overharvesting*.

Habitat Destruction is Usually the Main Threat

- The most important extinction threat for most species—especially terrestrial ones—is habitat loss.
- Over the past 10,000 years, humans have transformed billions of hectares of former forests and grasslands to croplands, cities, roads, and other uses.
- Sometimes we destroy habitat as a side effect of resource extraction, such as mining, dam-building, and indiscriminate fishing methods.

Historical Decrease in Forested Area in Southern Wisconsin

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1831



1882



1902



1950

Fragmentation Reduces Habitat to Small, Isolated Areas

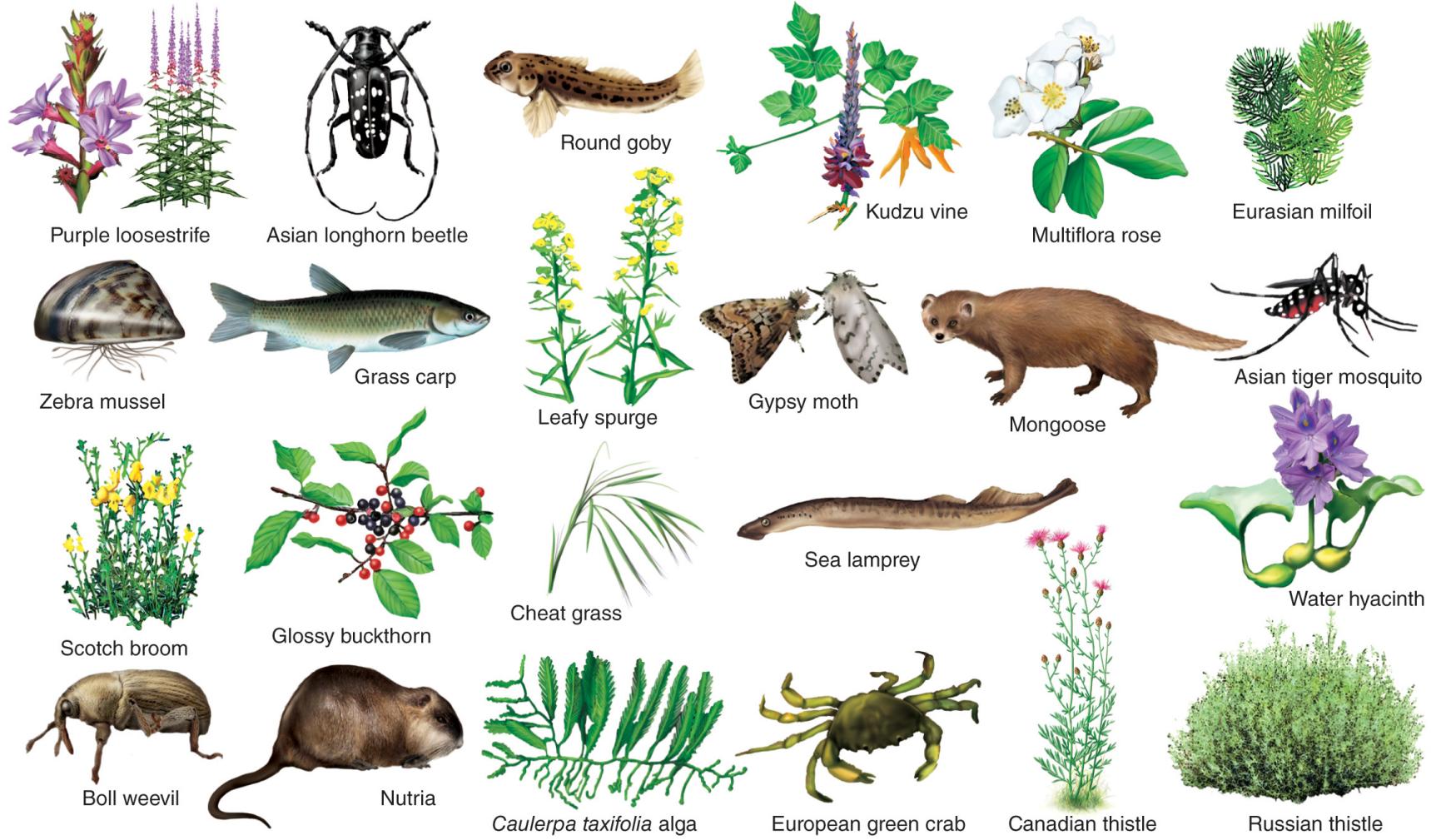
- **Habitat fragmentation** is the reduction of habitat into small, isolated patches.
- Breaking up habitat reduces biodiversity because many species, such as bears and large cats, require large territories to subsist.
- Other species, such as forest interior birds, reproduce successfully only in deep forest far from edges and human settlement.
- It can also divide populations into isolated groups, making them much more vulnerable to catastrophes.

Invasive Species are a Growing Threat

- A major threat to native biodiversity in many places is from accidentally or deliberately introduced species.
- **Invasive species** are organisms that thrive in new territory where they are free of predators, diseases, or resource limitations.
- Humans have always transported organisms into new habitats, but the rate of movement has risen sharply in recent years with the huge increase in speed and volume of travel by air, water, and land.

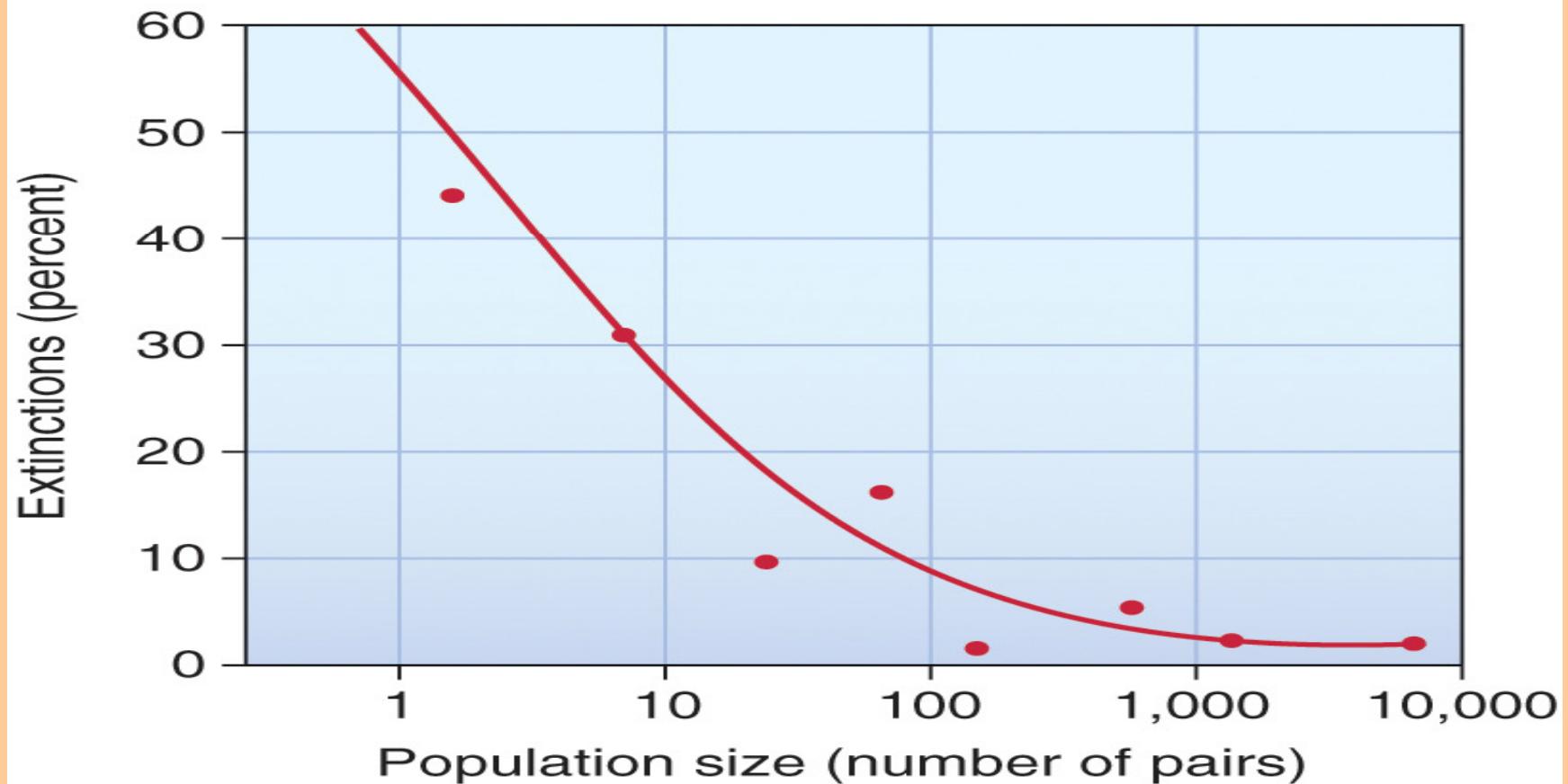
Invasive Species in North America

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Bird Extinction Rates in the Channel Islands

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Pollution Poses Many Types of Risk

- We have long known that toxic pollutants can have disastrous effects on local populations of organisms.
- The links between pesticides and the declines of fish-eating birds were well documented in the 1970s (fig. 5.28).
- Population declines are especially likely in species high in the food chain, such as marine mammals, alligators, fish, and fish-eating birds.
- Accumulation of DDT, PCBs, dioxins and lead in the food chain are a major cause of mortality.

Population Growth Consumes Space, Resources

- In the past 40 years, the global population has doubled from about 3.5 billion to about 7 billion.
- Even if per capita consumption patterns remain constant, more people will require more timber harvesting, fishing, farmland, and extraction of fossil fuels and minerals.

Overharvesting Depletes or Eliminates Species

- **Overharvesting** involves taking more individuals than reproduction can replace.
- A classic example is the extermination of the American passenger pigeon and the near extermination of the American Bison.
- Fish stocks have been seriously depleted by overharvesting in many parts of the world. At least three-quarters of all commercial oceanic species are overharvested.

Collectors Serve Medicinal and Pet Trades

- Despite international bans on trade in products from endangered species, smuggling of furs, hides, horns, live specimens, and folk medicines amounts to millions of dollars each year.
- The profits to be made in wildlife smuggling are enormous.
- Plants also are threatened by overharvesting for use in landscaping or as aphrodisiacs.

Parts from Rare and Endangered Species for Sale in China

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A Diver Uses Cyanide to Stun Fish for the International Aquarium Trade

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Predator and Pest Control Is Expensive But Widely Practiced

- Some animal populations have been greatly reduced, or even deliberately exterminated, because they are regarded as dangerous to humans or livestock or because they compete with our use of resources.
- Every year, U.S. government animal control agents trap, poison, or shoot thousands of coyotes, bobcats, prairie dogs, and other species considered threats to people, domestic livestock, or crops.

5.7 Endangered Species Protection

- Slowly, we are adopting national legislation and international treaties to protect our biological resources.
- Parks, wildlife refuges, nature preserves, zoos, and restoration programs have been established to protect nature and rebuild depleted populations.
- Most countries now have laws protecting endangered species and dozens of international treaties aim to reduce the decline of biodiversity worldwide.

Hunting and Fishing Laws

Protect Useful Species

- By the 1890s, though, most states had enacted some hunting and fishing restrictions.
- The general idea behind these laws was to conserve these resources for future human use rather than to preserve wildlife for its own sake.
- The wildlife regulations and refuges established since that time have been remarkably successful for many species.

The Endangered Species Act Protects Habitat and Species

What does the ESA do? It provides:

- (1) criteria for identifying species at risk,
- (2) directions for planning for their recovery,
- (3) assistance to land owners to help them find ways to meet both economic needs and the needs of a rare species, and
- (4) enforcement of measures for protecting species and their habitat.

Endangered Species Act Terminology

- The ESA identifies three levels of risk:
 - **Endangered species** are those considered in imminent danger of extinction.
 - **Threatened species** are likely to become endangered, at least locally, within the foreseeable future.
 - **Vulnerable species** are naturally rare or have been locally depleted by human activities to a level that puts them at risk.

IUCN Lists Species Internationally

- Worldwide, the International Union for Conservation of Nature and Natural Resources (IUCN) lists 17,741 endangered and threatened species.
- IUCN has no direct jurisdiction for slowing the loss of those species.
- Within the United States, the ESA provides mechanisms for reducing species losses.

Recovery Plans Aim to Rebuild Populations

- Once a species is listed, the Fish and Wildlife Service (FWS) is given the task of preparing a recovery plan.
- This plan details how populations will be stabilized or rebuilt to sustainable levels.
- A recovery plan could include many different kinds of strategies, such as buying habitat areas, restoring habitat, reintroducing a species to its historic ranges, captive breeding programs, and plans for negotiating the needs of a species and the people who live in an area.

ESA Species Terminology

- **Keystone species** are those whose elimination would affect many other members of the biological community.
- **Indicator species** are those tied to specific biotic communities, successional stages, or environmental conditions.
- **Umbrella species** require large blocks of relatively undisturbed habitat to maintain viable populations.
- **Flagship species** are especially interesting or attractive organisms to which people react emotionally.

The Bighorn Sheep is a Charismatic Species That Has Been Listed as Endangered

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Landowner Collaboration is Key

- Two-thirds of listed species occur on privately owned lands, so cooperation between federal, state, and local agencies as well as private and tribal land owners is critical for progress.
- Often the ESA is controversial because it can require that landowners change their plans for their land.
- On the other hand, many land owners and communities appreciate the value of biodiversity on their land and like the idea of preserving species.
- A number of provisions in the ESA protect landowners.

The ESA has Seen Successes and Controversies

- The ESA has held off the extinction of hundreds of species. Some have recovered and been delisted, including the brown pelican, the peregrine falcon, the American alligator and the bald eagle.
- However, political and legal debates can drag on over protecting a species for several years.
- Several famous controversies have occurred:
 - The Tennessee Valley Authority fought over protecting a fish called the snail darter from a proposed dam construction.
 - The timber industry fought over protecting the spotted owl.

"DAMN SPOTTED OWL!"



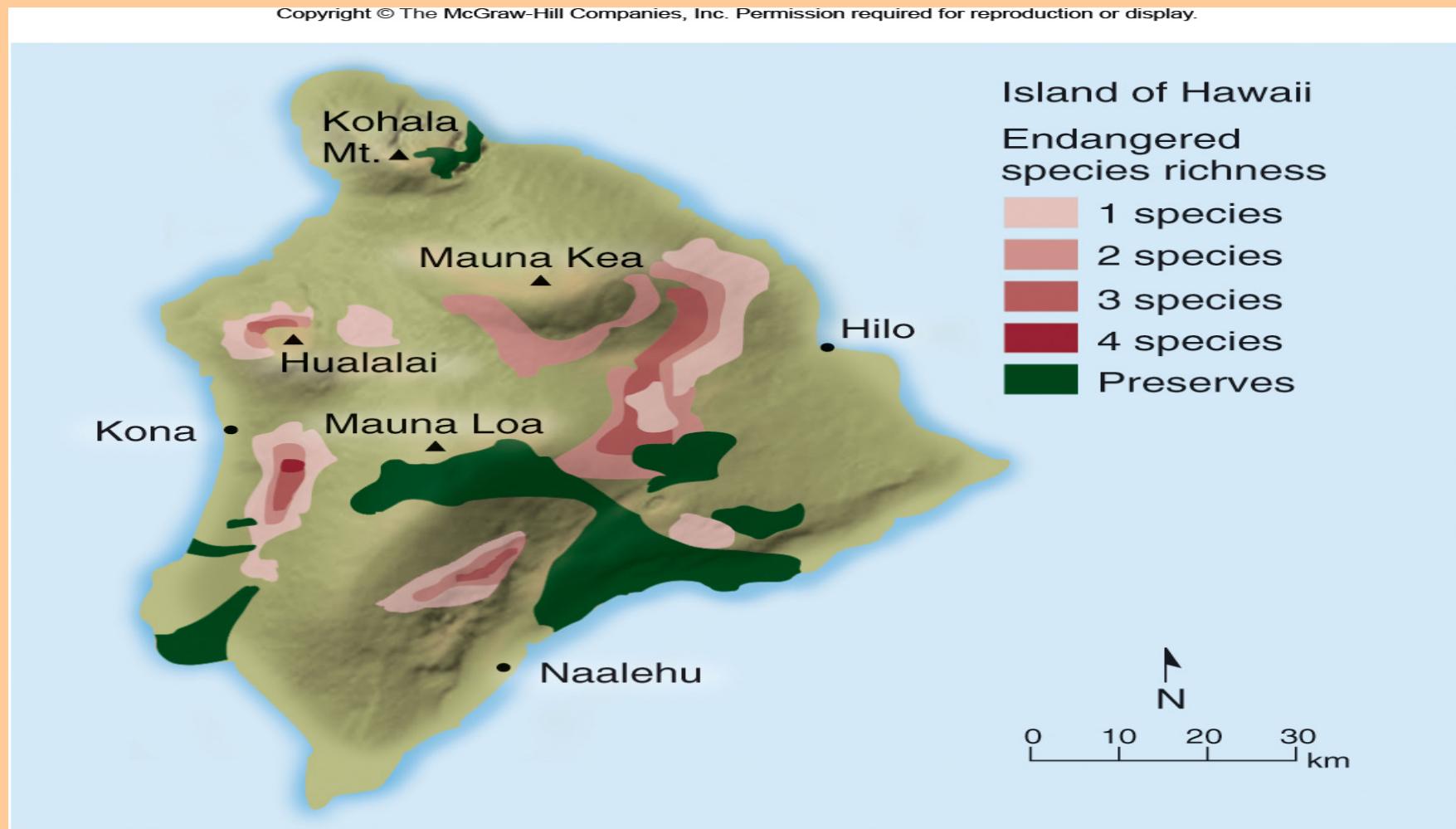
Many Countries Have Species Protection Laws

- Canada's Committee on the Status of Endangered Wildlife in Canada (COSEWIC) of 1977 establishes rules for listing and protecting endangered species.
- The European Union's Birds Directive (1979) and Habitat Directive (1991).
- Australia's Endangered Species Protection Act (1992).
- The Convention on Biological Diversity (1992) is an International agreement.
- The Convention on International Trade in Endangered Species (CITES) of 1975.

Habitat Protection May Be Better than Species Protection

- Growing numbers of scientists, land managers, policymakers, and developers are arguing that we need a rational, continent-wide preservation of ecosystems that supports maximum biological diversity.
- They argue that this would be more effective than species-by-species battles for desperate cases.

Sometimes Protected Lands Do Not Contain the Highest Species Diversity



Management Principles for Protecting Biodiversity in the Future

Conservation biologist R. E. Grumbine suggests 4 principles for protecting biodiversity in a large-scale, long-range approach:

1. Protect enough habitat for viable populations of all native species in a given region.
2. Manage at regional scales large enough to accommodate natural disturbances.
3. Plan over a period of centuries, so that species and ecosystems can continue to evolve.
4. Allow for human use and occupancy at levels that do not result in significant ecological degradation.

Conclusion

- Biodiversity can be understood in terms of the environmental conditions where different organisms live, in terms of biomes, and in terms of habitat types.
- Of the world's species, many are threatened or endangered.
- Biodiversity is important to us because it aids in ecosystem stability but many factors threaten biodiversity today. HIPPO describes these threats.