3

The Biosphere

- *Case Study*: The American Serengeti: Twelve Centuries of Change in the Great Plains
- Terrestrial Biomes
- Freshwater Biological Zones
- Marine Biological Zones
- *Case Study Revisited*
- *Connections in Nature*: Long-Term Ecological Research

General overview – be familiar with the different biomes and zones, particularly Fig. 3.4

Case Study: The American Serengeti: Twelve Centuries of Change in the Great Plains

The Serengeti Plain of Africa has a high diversity of wild animals

- In contrast, the Great Plains of North America have very low diversity: Large stands of uniform crop plants and a few species of domesticated herbivores

ECOLOGY, Figure 3.1

v.nationalgeographic.com/lewisandclark/images/movie/photogallery_large/20_b.jpg

Figure 3.1 The Serengeti Plain of Africa

ECOLOGY, Figure 3.1

Case Study: The American Serengeti: Twelve Centuries of Change in the Great Plains

In North America, the last continental glaciers were receding about 13,000 years ago

- Great Plains supported a high diversity of megafauna:
  - Woolly mammoths and mastodons, several species of horses, camels, giant ground sloths, saber-toothed cats, cheetahs, lions, and giant short-faced bears

ECOLOGY, Figure 3.2

Figure 3.2 Pleistocene Animals of the Great Plains

Artist reconstruction of a Lower Pecos scene in the Late Pleistocene geological era, about 25,000 years ago. Then, the climate was cooler and wetter and supported extensive grasslands where mammoths, camels, bison, and other "Ice Age" species roamed. Painting by George Strickland from Ancient Texans: Rock Art and Lifeways along the Lower Pecos, 1986, courtesy Witte Museum of San Antonio.

http://www.texasbeyondhistory.net/hinds/images/Pleistocene.jpg

Case Study: The American Serengeti: Twelve Centuries of Change in the Great Plains

About 10,000–13,000 years ago, many North American large mammals of went extinct

- Approximately 28 genera (40–70 species) went extinct over a short time period
- Nearly all animals that went extinct were large mammals

http://www.texasbeyondhistory.net/hinds/images/Pleistocene.jpg

Case Study: The American Serengeti: Twelve Centuries of Change in the Great Plains

Causes of the Great Plains Pleistocene extinctions are a mystery to paleontologists. Hypotheses include…

- rapid climate change (changes in habitat and food supply) and…
- arrival of humans (over hunting)in North America
  - Human's role in these extinctions has been controversial

http://msnbcmedia2.msn.com/j/msnbc/Components/Photo_StoryLevel/080401/080401-science-mammoth-hlarge-830a.hlarge.jpg

Living things are found on every part of Earth, from the highest mountains to the deepest oceans

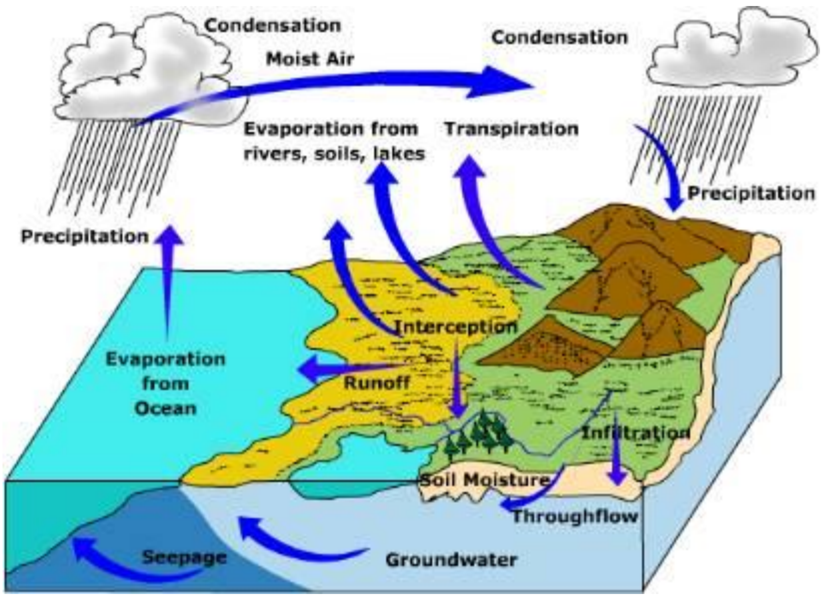
- Bacteria and archaea are found everywhere, even on dust high in the atmosphere, under ice sheets, and in deep oil reserves below the surface
- But *most organisms* occur within a thin veneer of Earth's surface, from the tops of trees to the surface soil layers, and within 200 meters of the surface of the oceans

Jump to Slide #23

Introduction

The **biosphere** is the zone of life on Earth

- It lies between the **lithosphere** — Earth's surface crust and upper mantle, and the *troposphere* — the lowest layer of the atmosphere
- Biological communities can be categorized at multiple scales of varying complexity

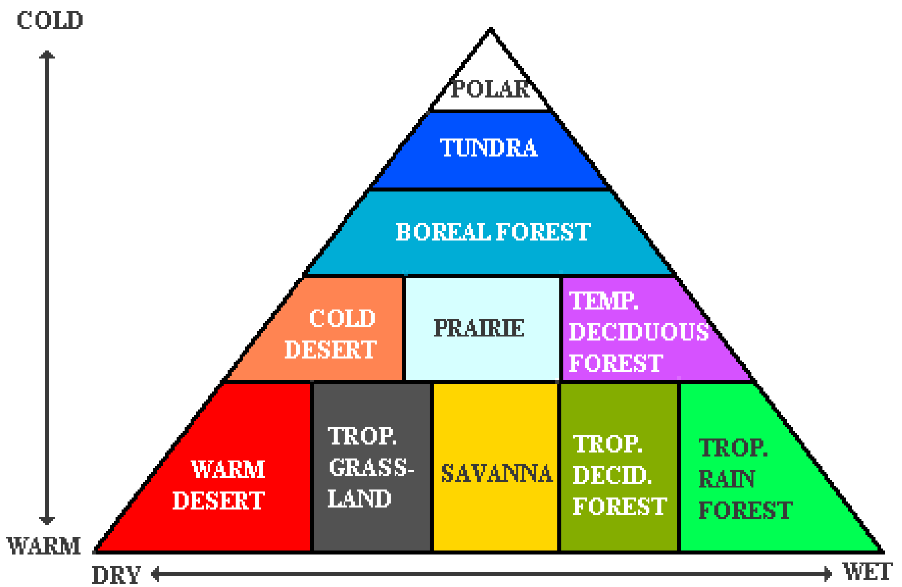


http://www.uwsp.edu/geo/faculty/ritter/images/hydrosphere/hydrocyc_small.jpg

Concept 3.1: Terrestrial biomes are characterized by the dominant growth forms of vegetation.

Biomes

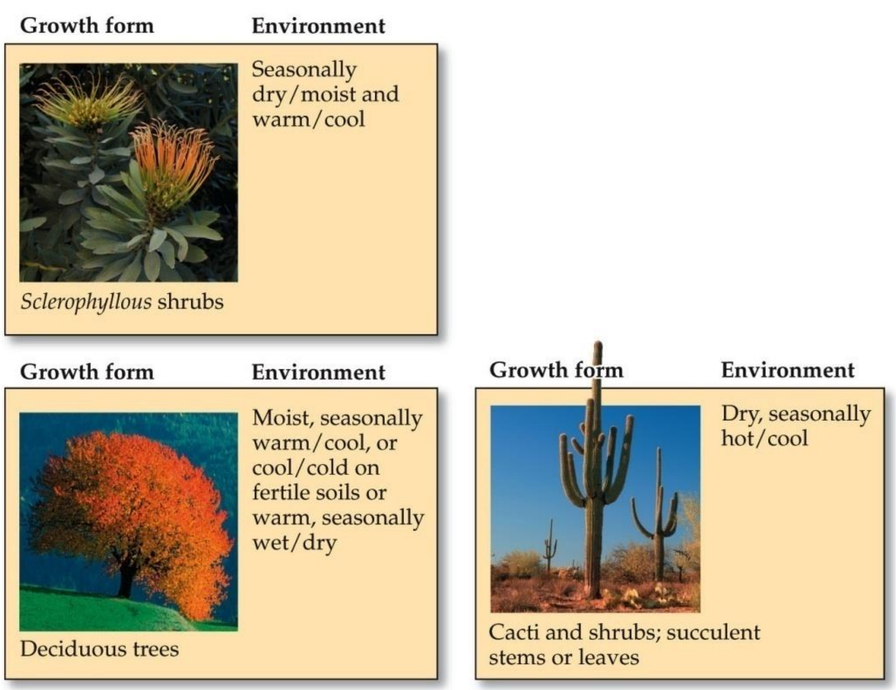
- large biological communities shaped by the physical environment, particularly climatic variation



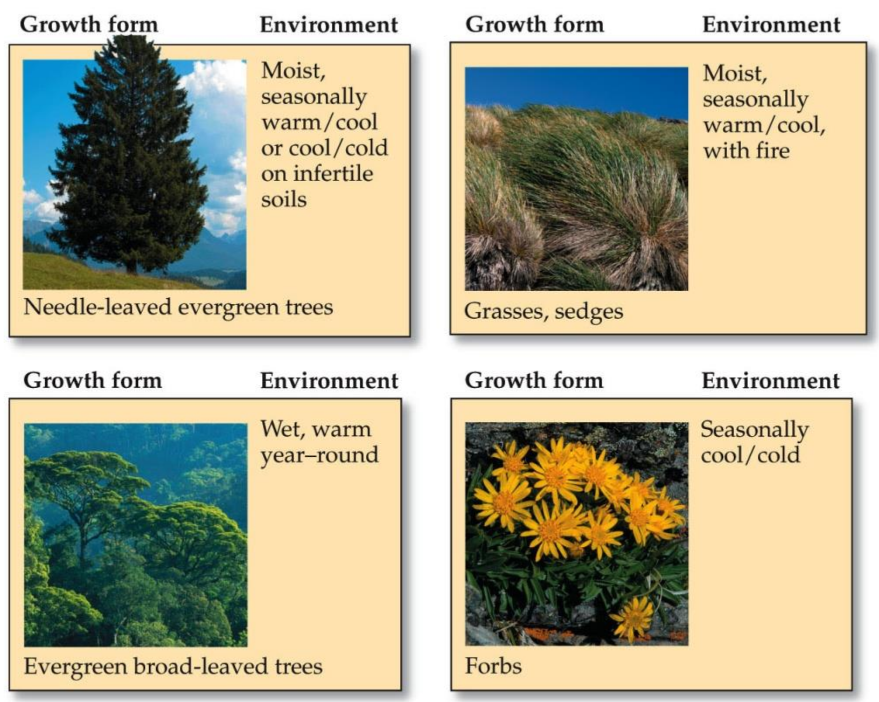
http://www.msad40.org/mvhs/library/images/BIOMES.GIF

Terrestrial Biomes

- Biomes are based on *similarities in morphological responses* of organisms to the physical environment, not on taxonomic similarities
- Terrestrial biomes are classified by growth form of the most abundant plants



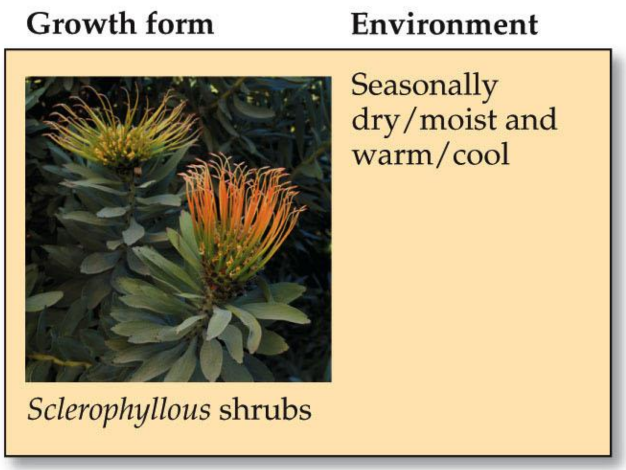
***ECOLOGY*, Figure 3.3 (Part 1)**

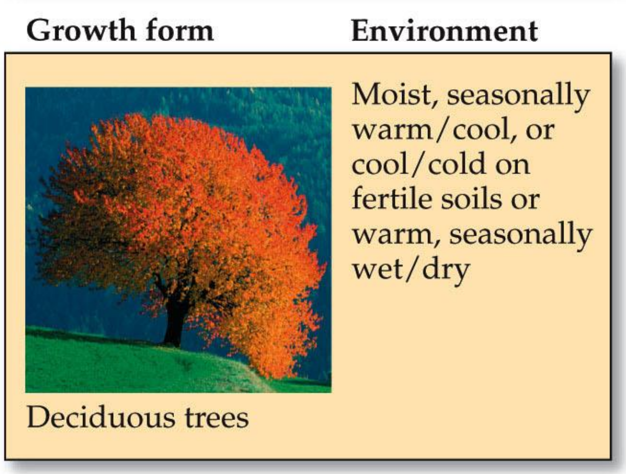


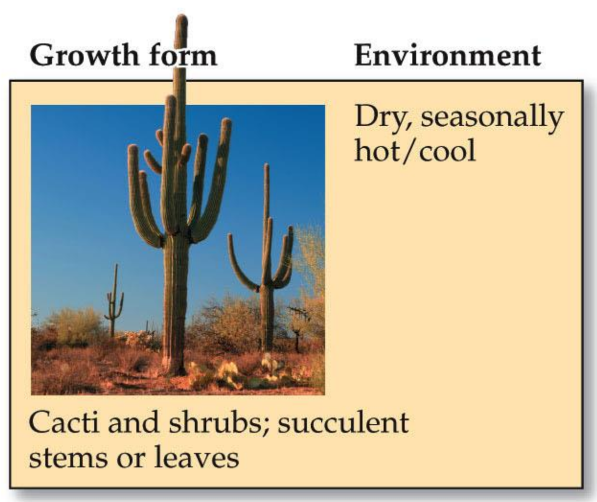
***ECOLOGY*, Figure 3.3 (Part 2)**

Leaf characteristics may be used:

- *Deciduousness* — seasonal shedding of leaves (based on temperature or rainfall)
- Thickness
- *Succulence* — development of fleshy water storage tissues





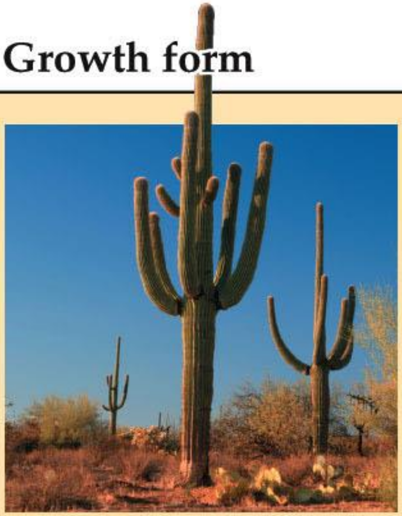


***ECOLOGY*, Figure 3.3 (Part 1)**

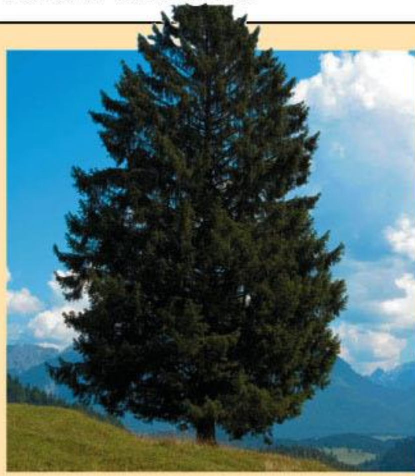
Figure 3.3 Plant Growth Forms (Part 1)

Growth form	Environment
 *Sclerophyllous* shrubs	Seasonally dry/moist and warm/cool

Growth form	Environment
 Deciduous trees	Moist, seasonally warm/cool, or cool/cold on fertile soils or warm, seasonally wet/dry

Growth form	Environment
 Cacti and shrubs; succulent stems or leaves	Dry, seasonally hot/cool

Growth form | **Environment**



Moist, seasonally warm/cool or cool/cold on infertile soils

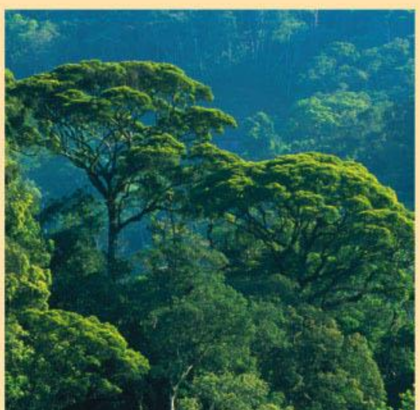
Needle-leaved evergreen trees

Growth form | **Environment**

Moist, seasonally warm/cool, with fire

Grasses, sedges

Growth form | **Environment**



Wet, warm year–round

Evergreen broad-leaved trees

Growth form | **Environment**

Seasonally cool/cold

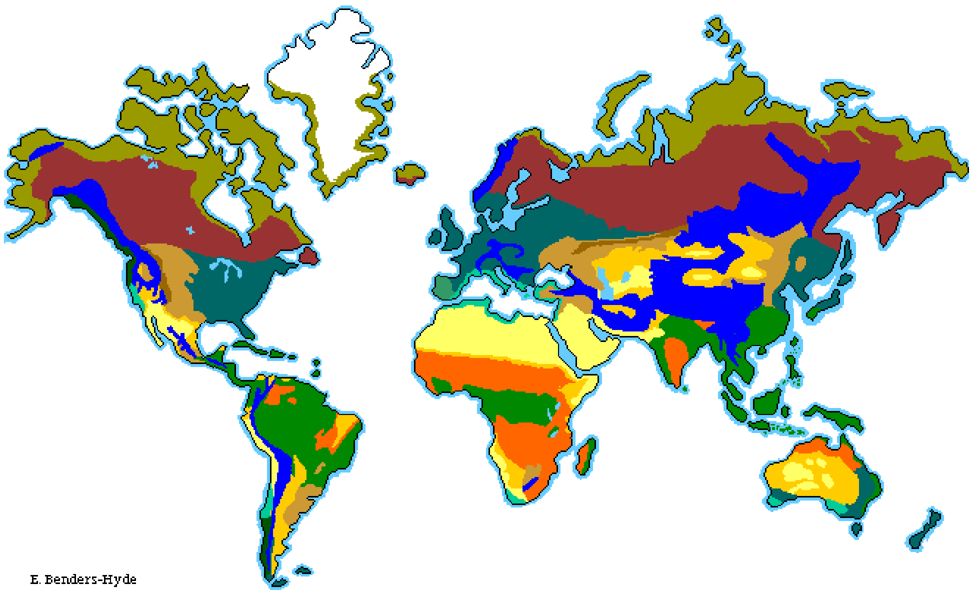
Forbs

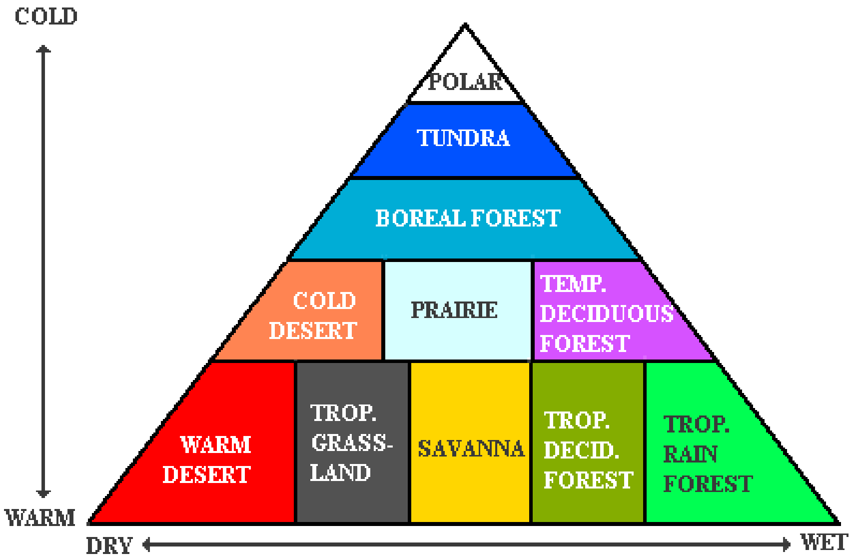
ECOLOGY, **Figure 3.3 (Part 2)**

Terrestrial Biomes

Biomes provide introduction to diversity of life on Earth

- Convenient unit for modelers simulating the effects of climate change and effects of biota on climatic system

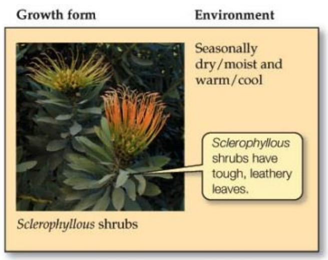


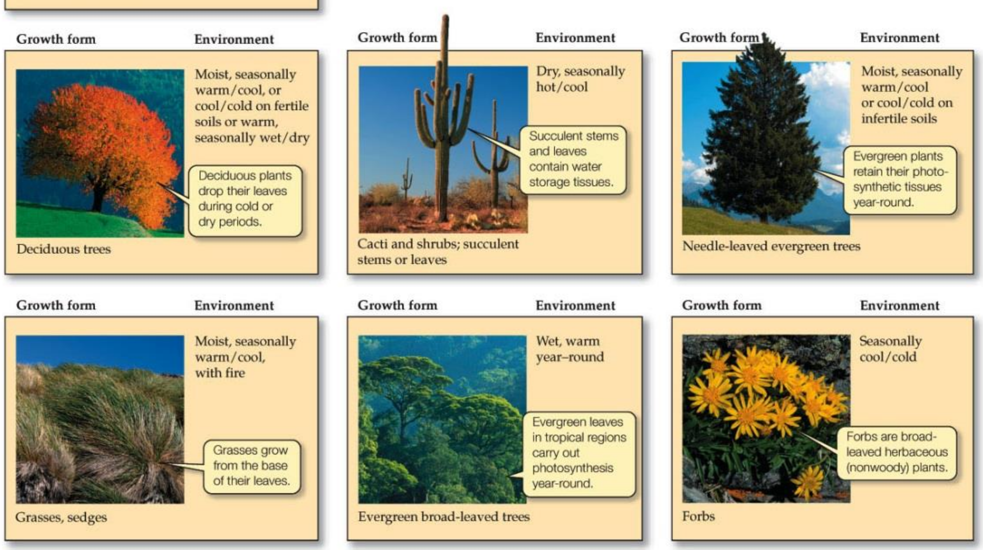


http://www.msad40.org/mvhs/library/ScienceLinksMVHS.cfm

Plant growth forms are good indicators of the physical environment

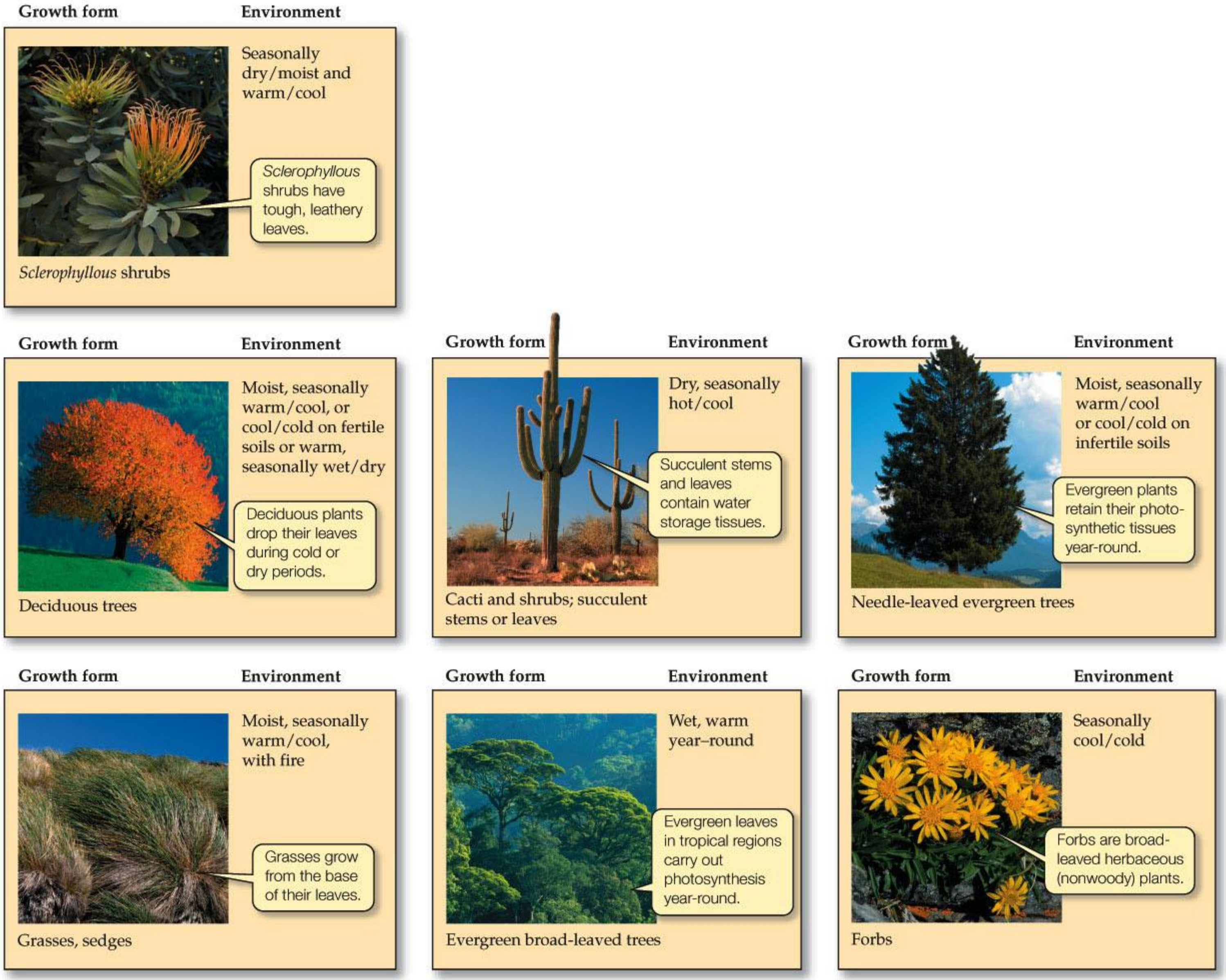
- Reflect climatic zones and rates of disturbance
- Plants are immobile and must cope with environmental extremes and biological pressures, such as competition, to successfully occupy a site for a long time





***ECOLOGY*, Figure 3.3**

Figure 3.3 Plant Growth Forms



Terrestrial Biomes

Selection pressures of the terrestrial environment include…

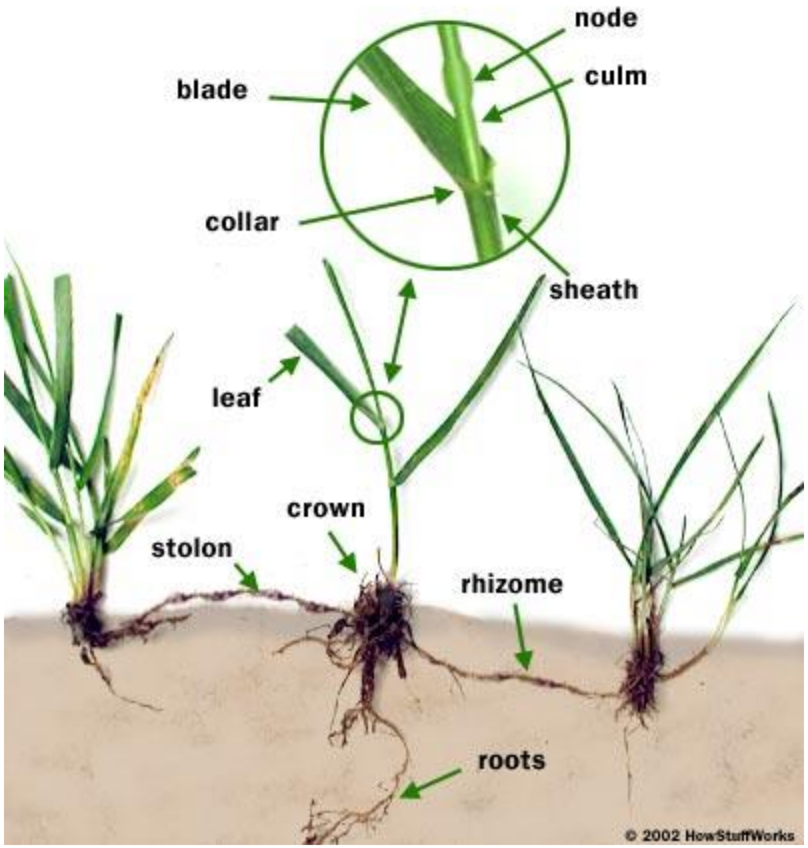
- aridity
- high and subfreezing temperatures
- intense solar radiation
- grazing by terrestrial animals, and…
- crowding by neighbors

- Plants have adapted to these pressures in many ways…
  - For example, deciduous leaves are a way to deal with seasonal aridity or cold

Perennial grasses are tolerant of grazing, fire, subfreezing temperatures, and dry soils

- Tolerance due to their vegetative and reproductive buds are below the soil surface (**basal meristem**)
- Similar growth forms can be found on different continents, even though the plants are not genetically related.

Grass stem grow from their base at the crown, which is often low to the ground or underground



http://static.howstuffworks.com/gif/grass-diagram.jpg

Convergence

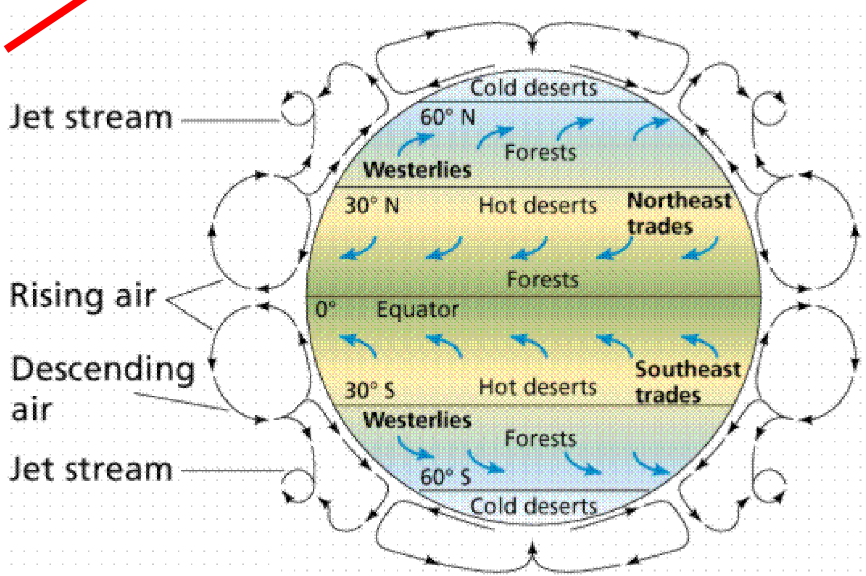
- Evolution of similar growth forms among distantly related species in response to similar selection pressures

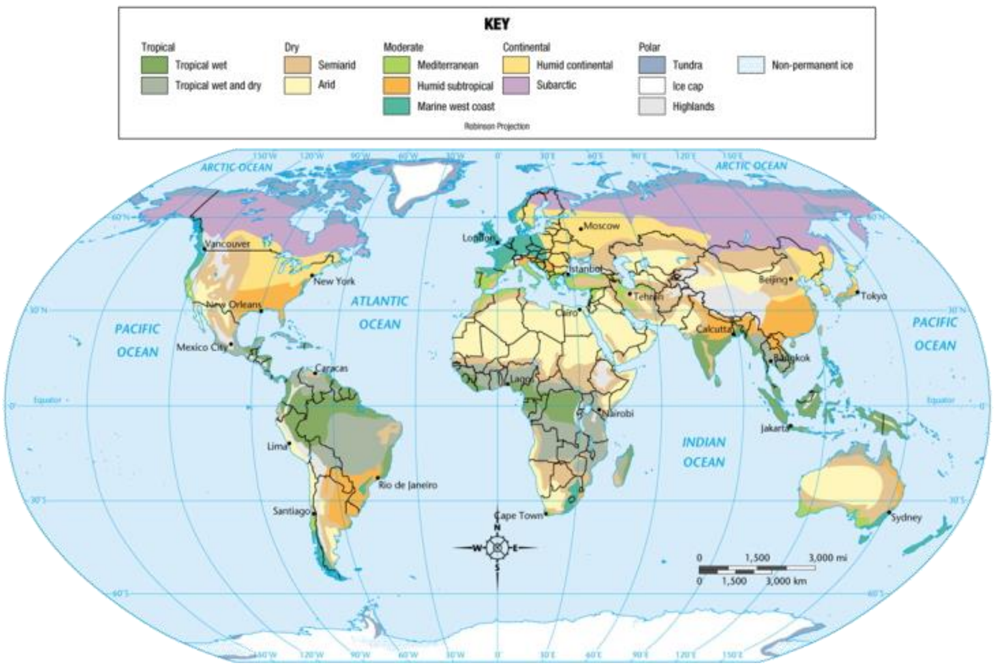
These unrelated twining, parasitic plants lack chlorophyll and absorb nutrients from their host plants be means of specialized roots called haustoria. Left: ***Cassytha filiformis*** (Lauraceae) on the Caribbean Island of Grand Cayman. Right: ***Cuscuta californica*** (Convolvulaceae or Cuscutaceae).

http://waynesword.palomar.edu/evolutio.htm

Climatic zones that are a consequence of atmospheric and oceanic circulation patterns are the major determinants of the distribution of terrestrial biomes

- For example, *major hot deserts of the world are associated with zones of high pressure at about 30° N and S*



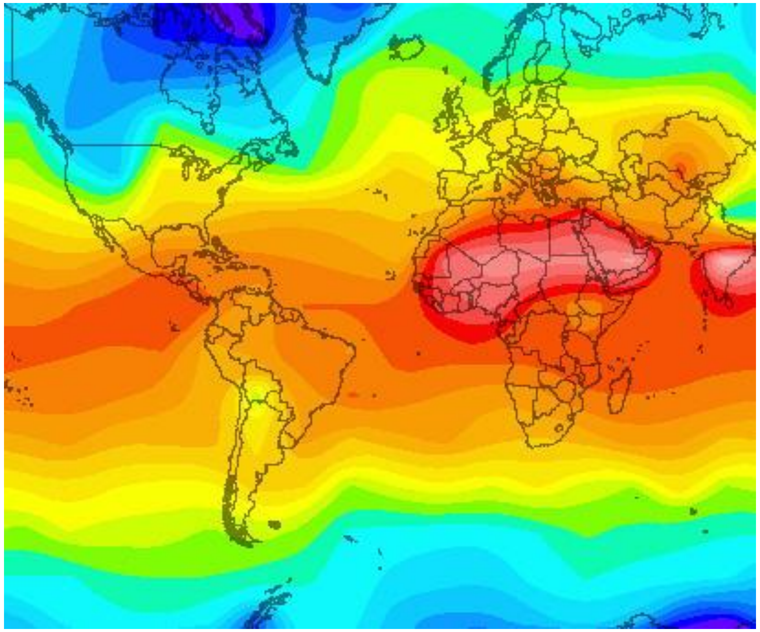


http://www.globalchange.umich.edu/globalchange2/current/2007/Labs/Unit%

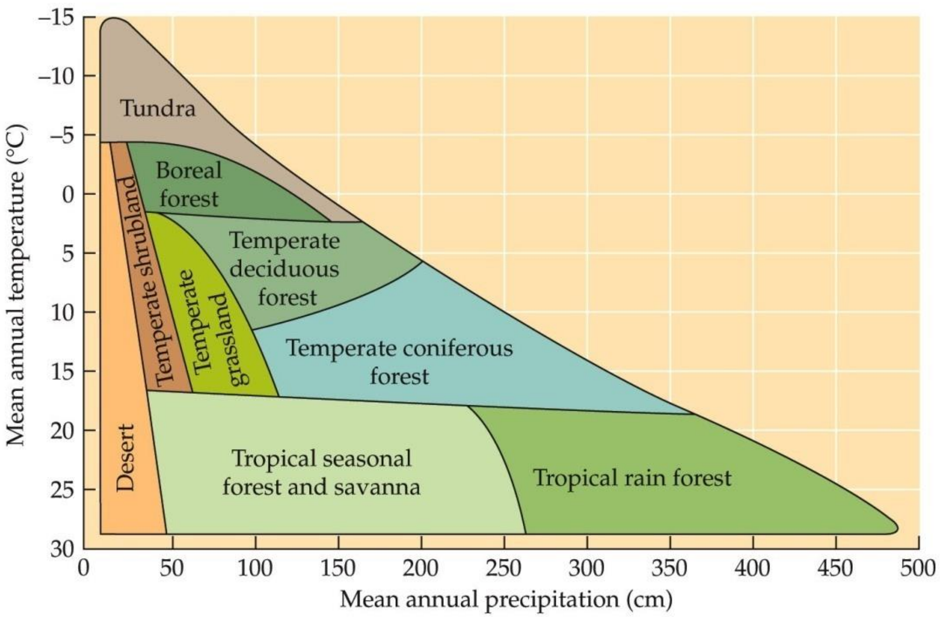
http://upload.wikimedia.org/wikibooks/en/c/c2/ClimateMapWorld.png

Temperature influences distribution of plant growth forms directly through physiological effects

- Precipitation and temperature act together to influence water availability and water loss by plants
- Water availability and soil temperature determine nutrient supply in the soil



http://www.jeffsweather.com/archives/global%20temps%20rise.jpg

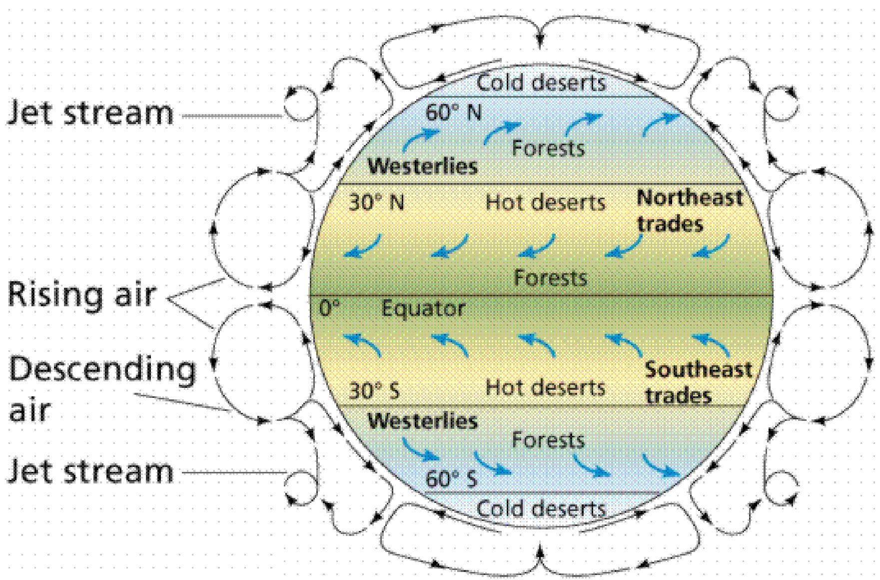


ECOLOGY, Figure 3.4

Terrestrial Biomes

- Average annual temperature and precipitation can predict biome distributions quite well, but seasonal variation is also important
  - Climatic extremes can sometimes be more important than average conditions

Really important!!



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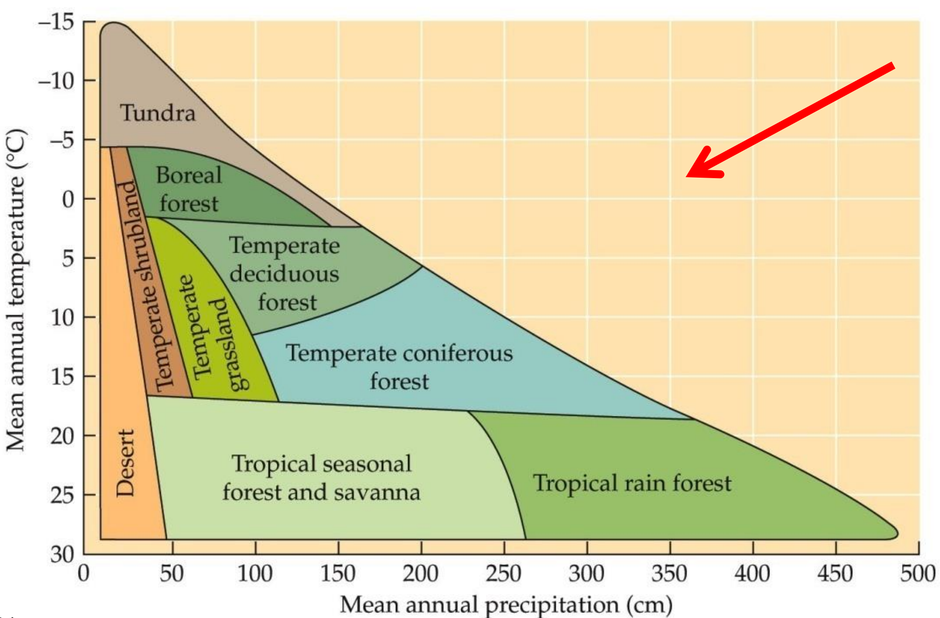
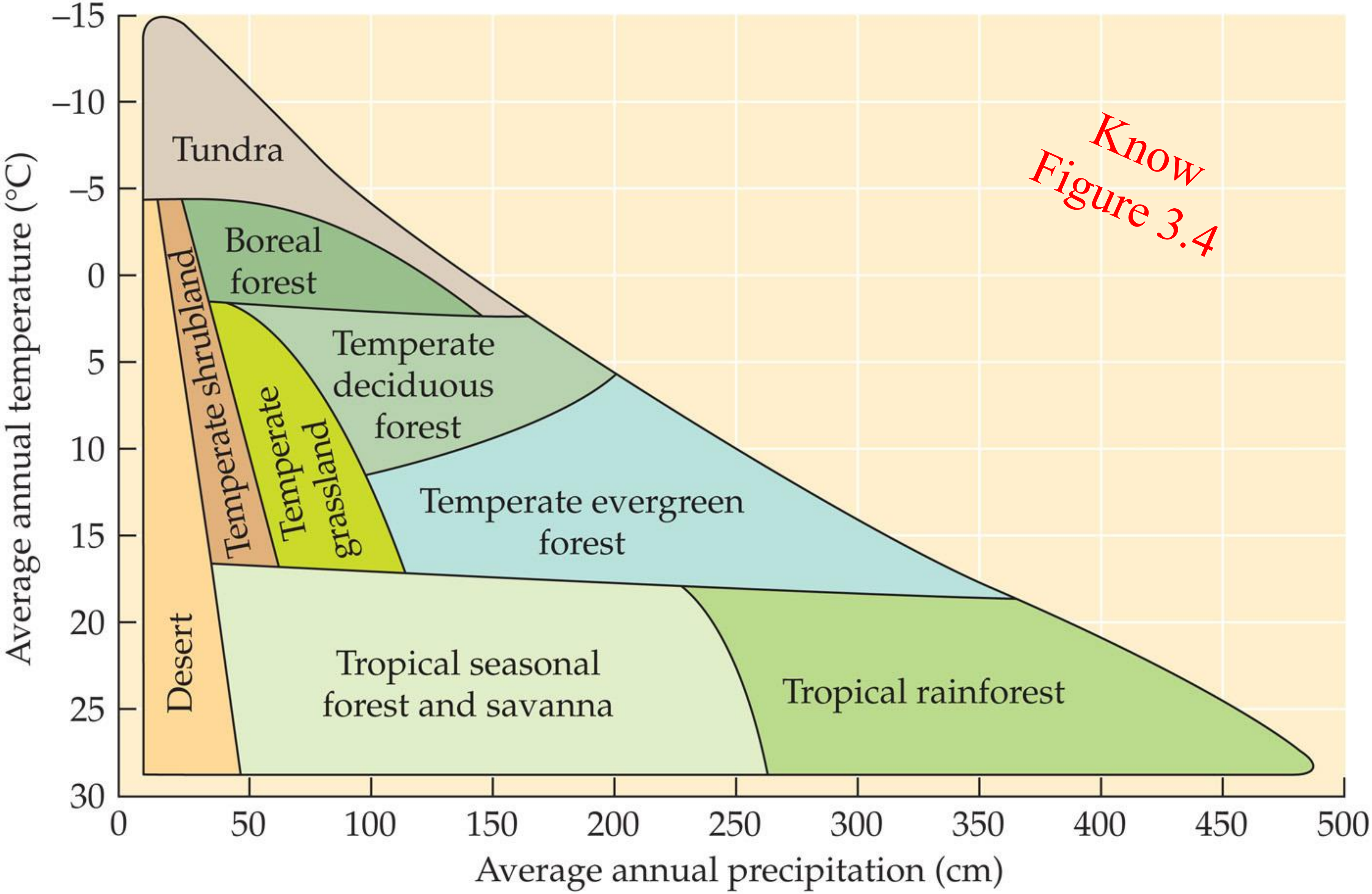


ECOLOGY, Figure 3.4

Figure 3.4 Biomes Vary with Mean Annual Temperature and Precipitation

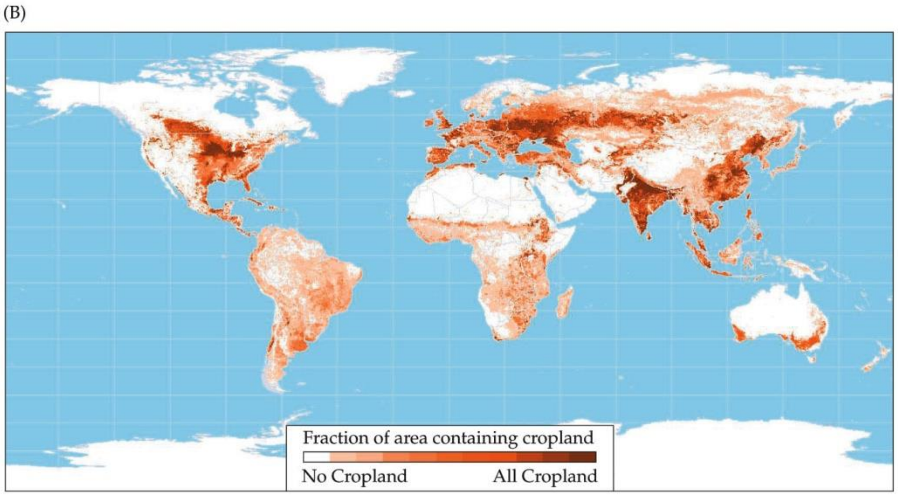
http://www.globalchange.umich.edu/globalchange2/current/2007/Labs/Unit%203b2007_files/image005.gif

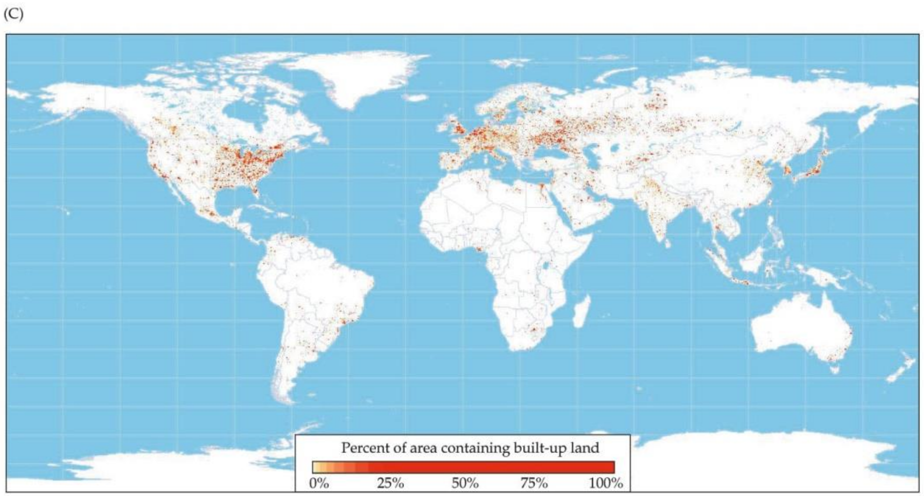


ECOLOGY 3e, **Figure 3.4**

Human activities influence the distribution of biomes

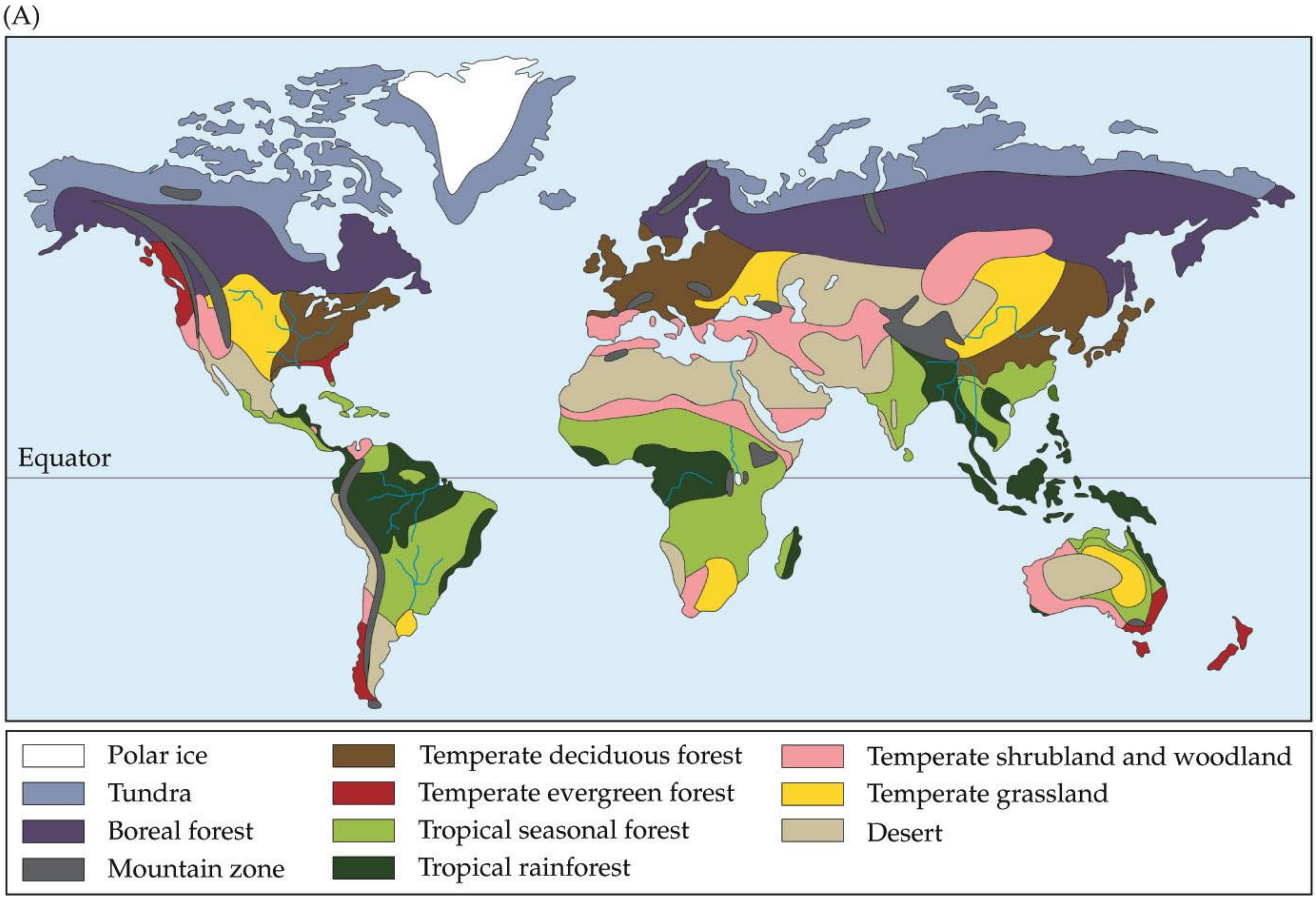
- **Land use change**: Conversion of land to agriculture, logging, resource extraction, urban development
- The potential and actual distributions of biomes are markedly different





ECOLOGY, Figure 3.5 (Part 2)

Figure 3.5 A Global Biome Distributions Are Affected by Human Activities



***ECOLOGY*, Figure 3.5 (Part 1)**

Figure 3.5 B Global Biome Distributions Are Affected by Human Activities

(B)

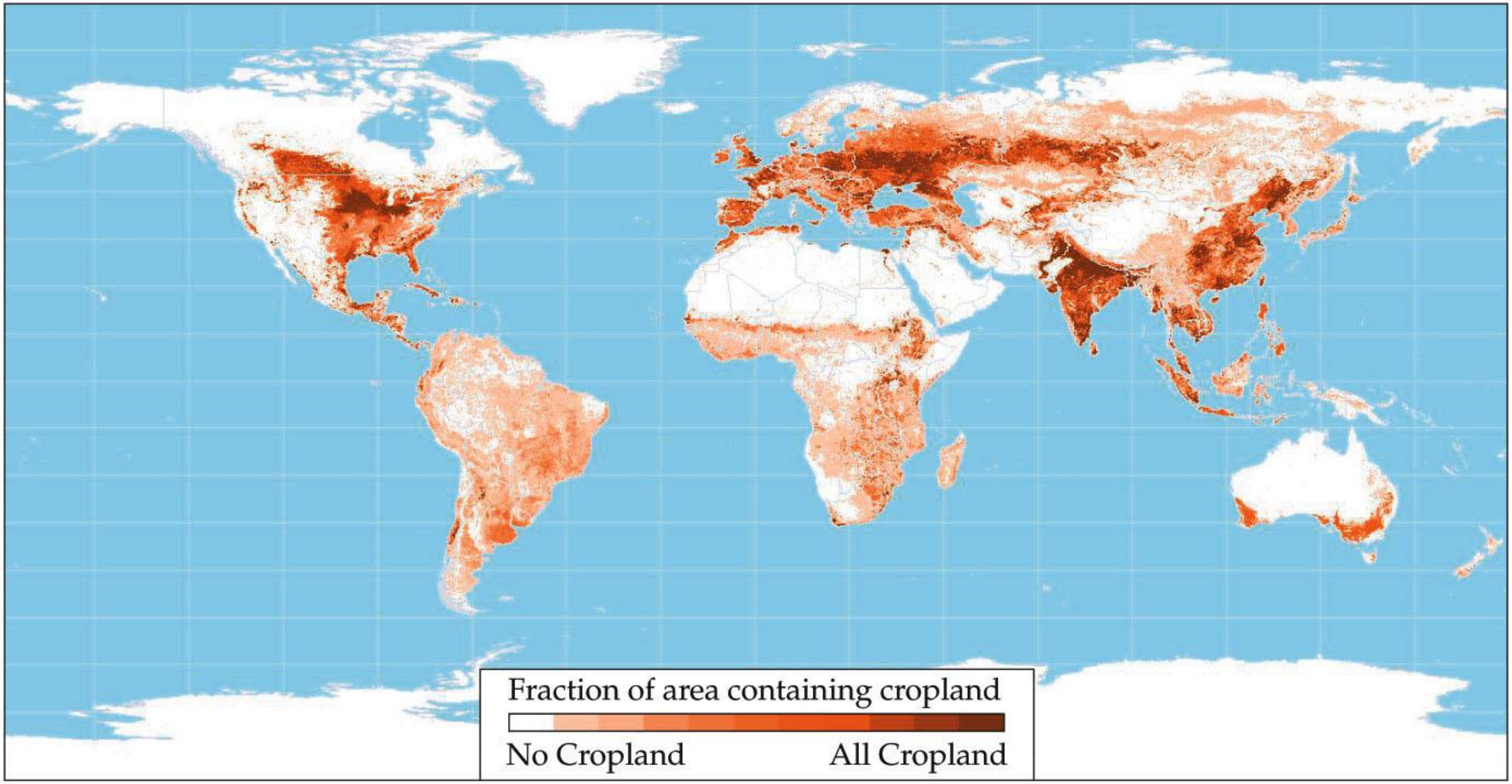
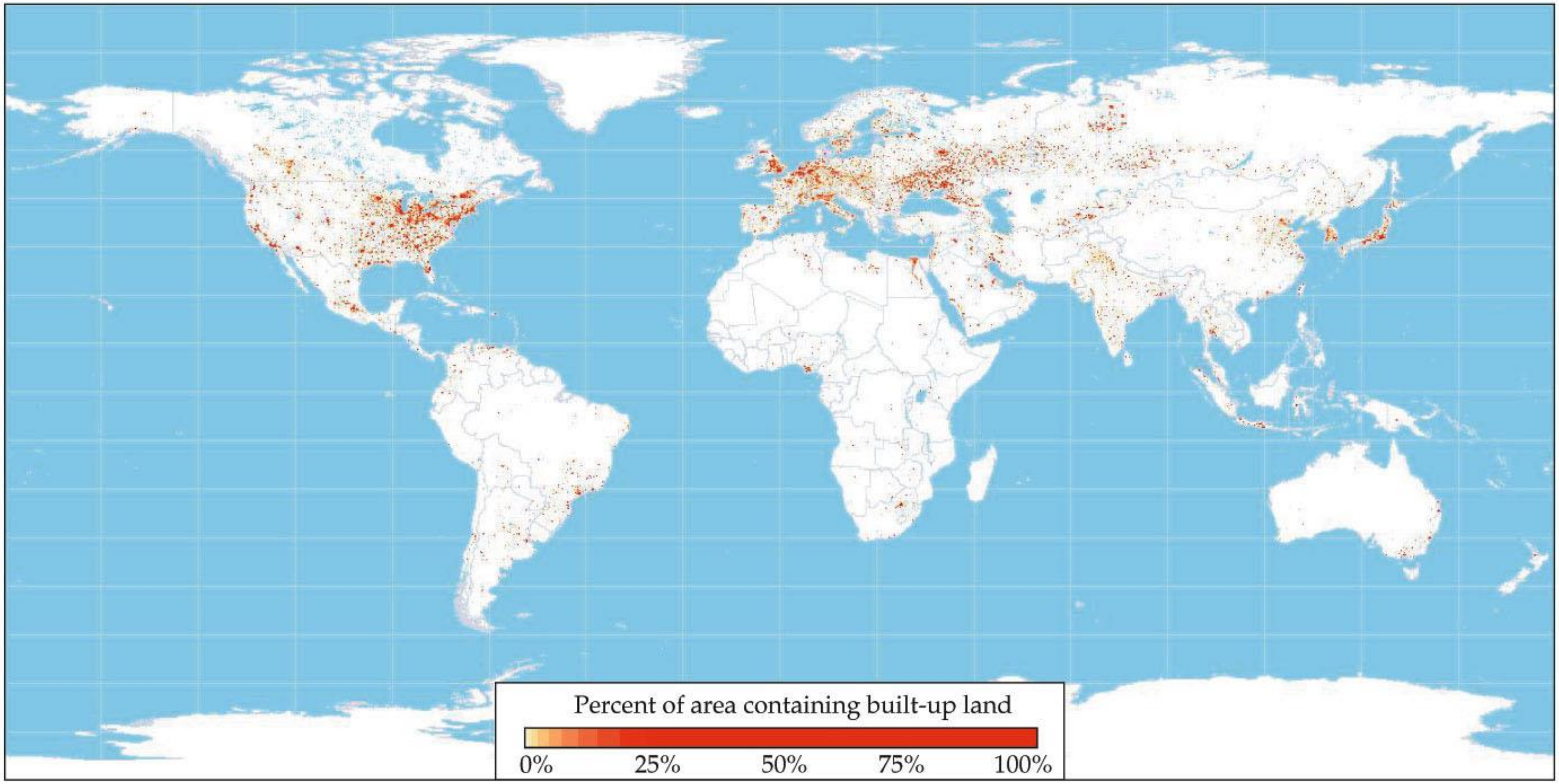


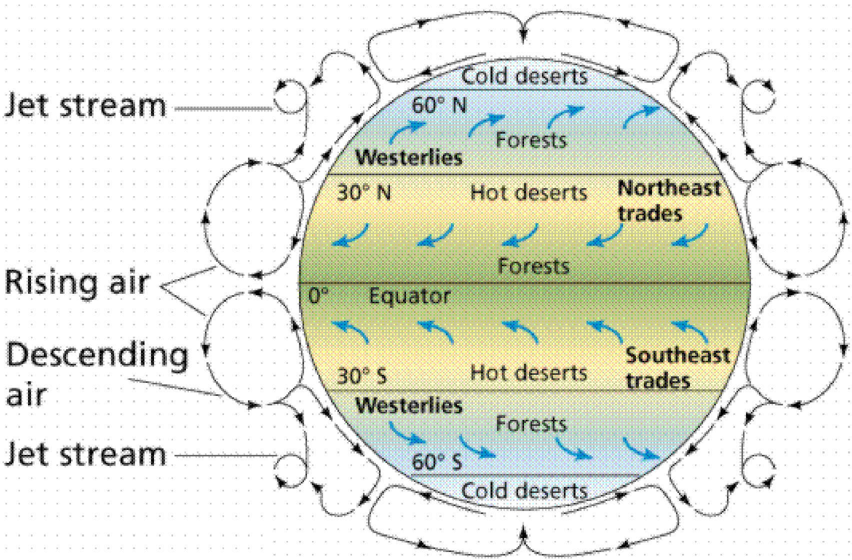
Figure 3.5 C Global Biome Distributions Are Affected by Human Activities

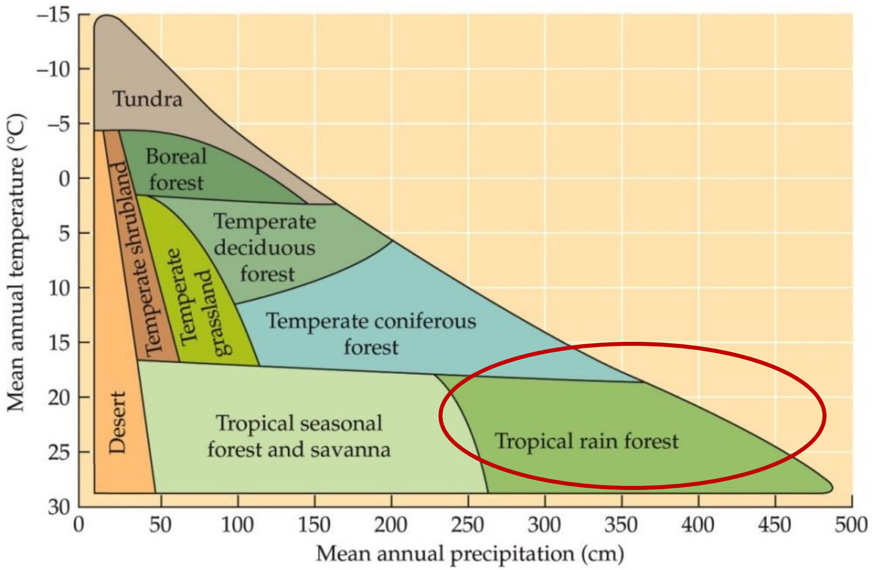
(C)



http://www.globalchange.umich.edu/globalchange2/current/2007/Labs/Unit%203b2007_files/image005.gif

Terrestrial Biomes





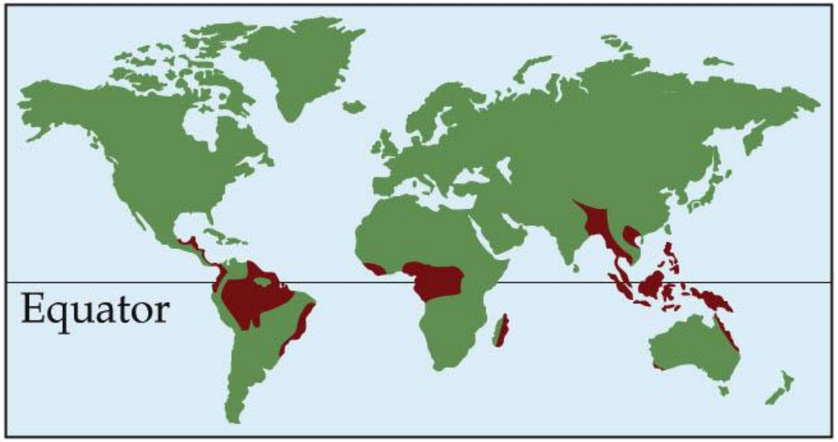
ECOLOGY, Figure 3.4

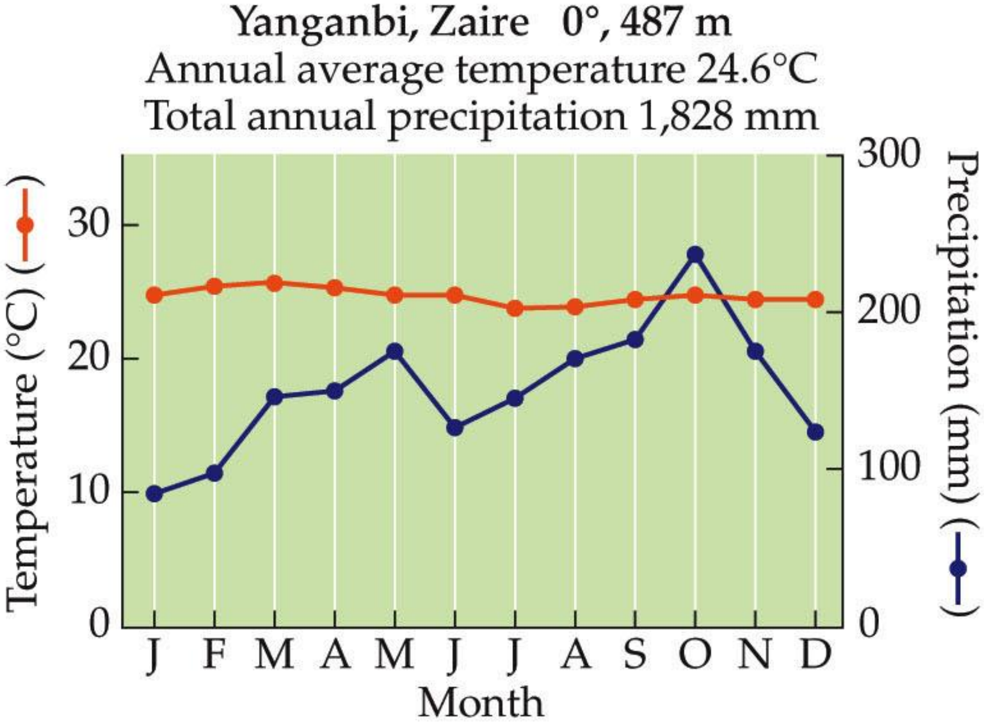
Tropical Rainforests:

- Between 10° N and S
- Annual precipitation > 200 cm
- No or little seasonal changes
- High biomass, high diversity – ~50% of Earth’s species in only ~11% of vegetation cover
- Broadleaved evergreen and deciduous trees

Jump to Slide 94

TROPICAL RAINFORESTS



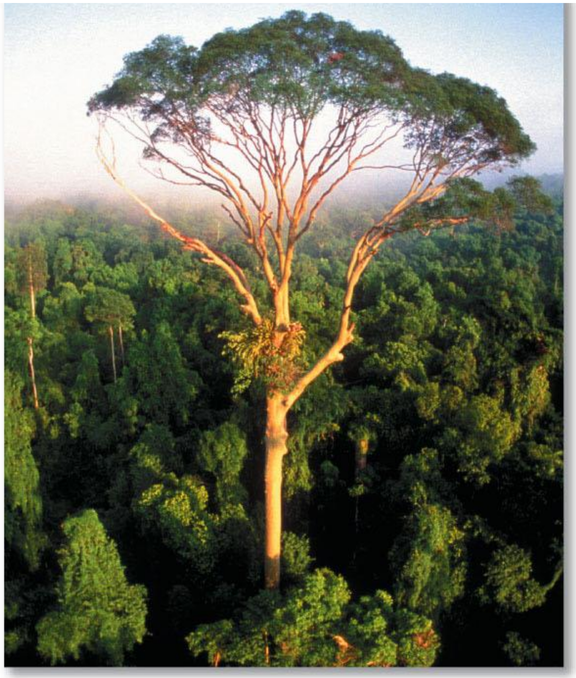


***ECOLOGY,* Figure 3.A (Part 1)**

Terrestrial Biomes

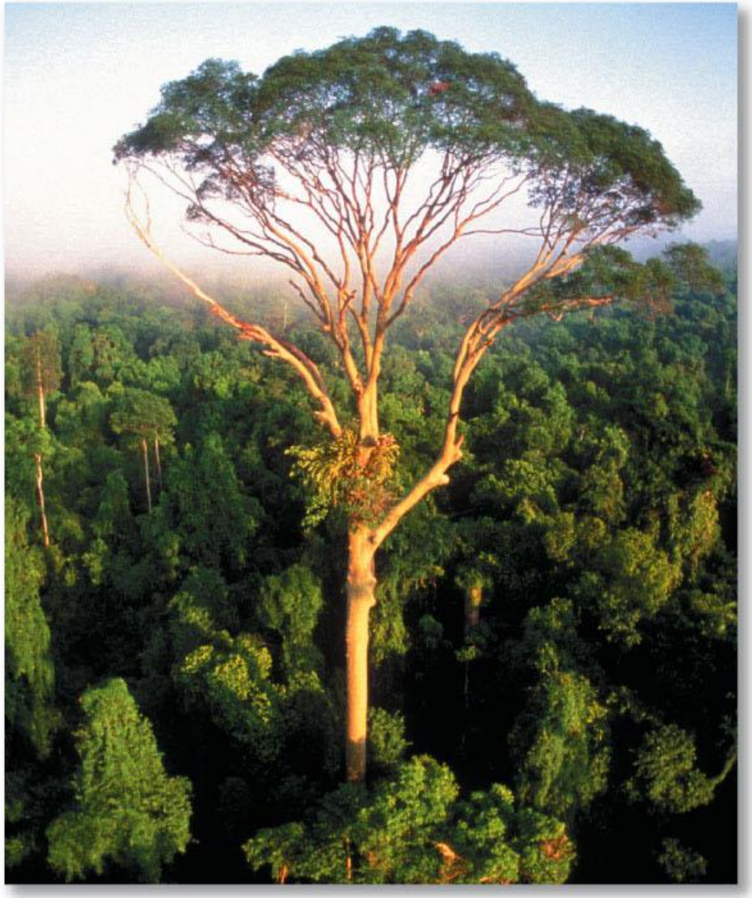
- Light is an important factor — plants grow very tall above their neighbors or must adjust to low light levels
- ***Emergents*** rise above *canopy* — a continuous layer about 30–40 m high
- ***Lianas*** (woody vines) and *epiphytes* use trees for support
- ***Understory*** trees grow in the shade of the canopy, and ***shrubs*** and ***forbs*** occupy the forest floor

Trees, shrubs, and epiphytes crowd a rainforest below the canopy, Napo, Ecuador



Emergent tree with epiphytes rises above the forest canopy, Borneo

TROPICAL RAINFORESTS

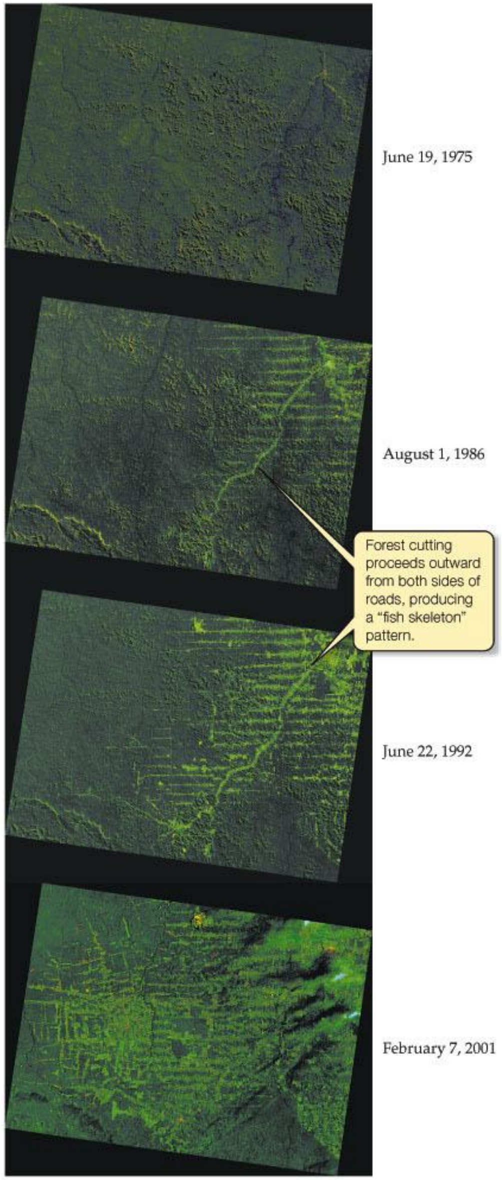


Emergent tree with epiphytes rises above the forest canopy, Borneo

Trees, shrubs, and epiphytes crowd a rainforest below the canopy, Napo, Ecuador

Tropical rainforests are disappearing rapidly due to logging and conversion to pasture and croplands.

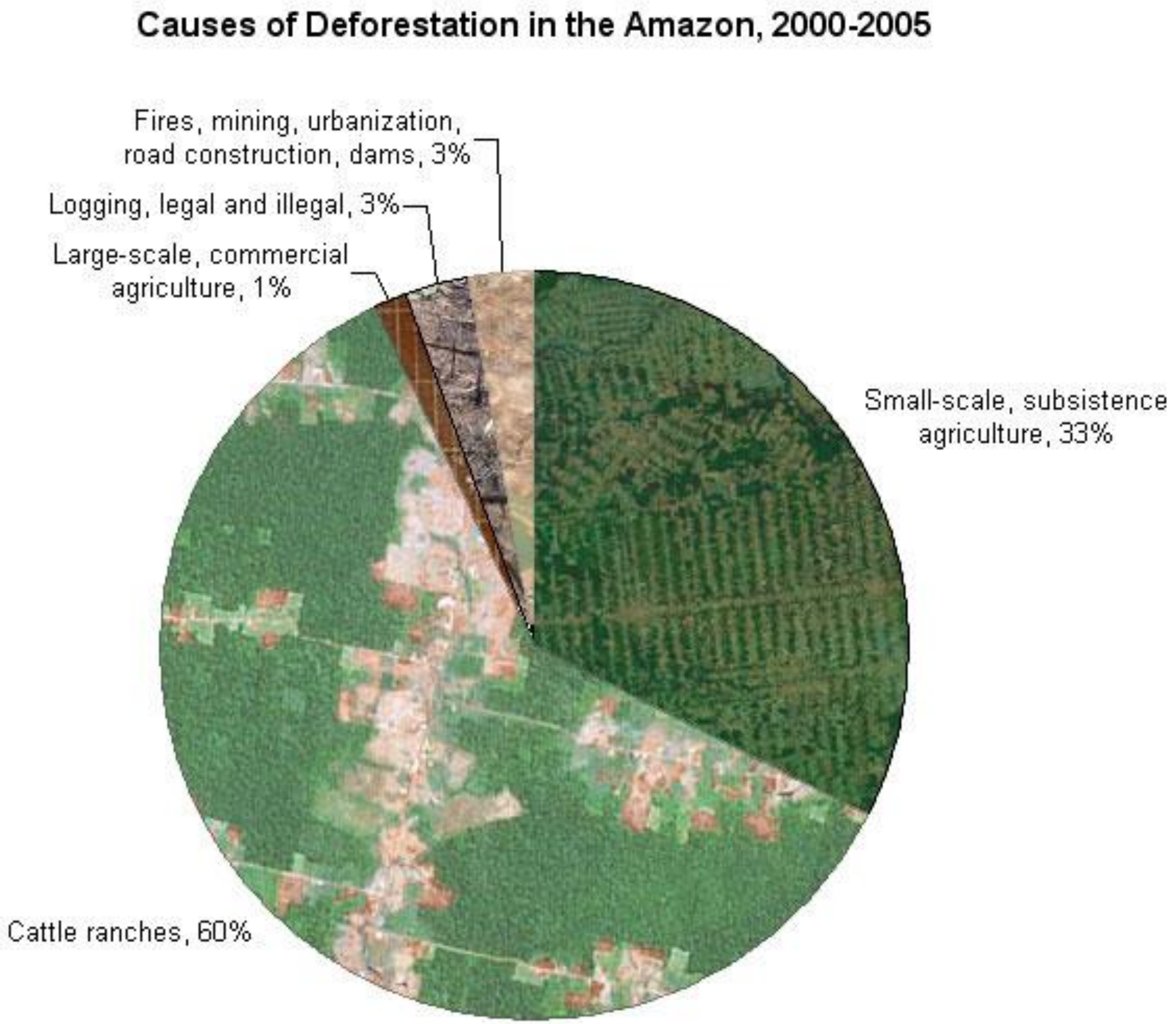
- About half of the tropical rainforest biome has been altered.
- Recovery of rainforests is uncertain; soils are often nutrient-poor, and recovery of nutrient supplies may take a very long time.

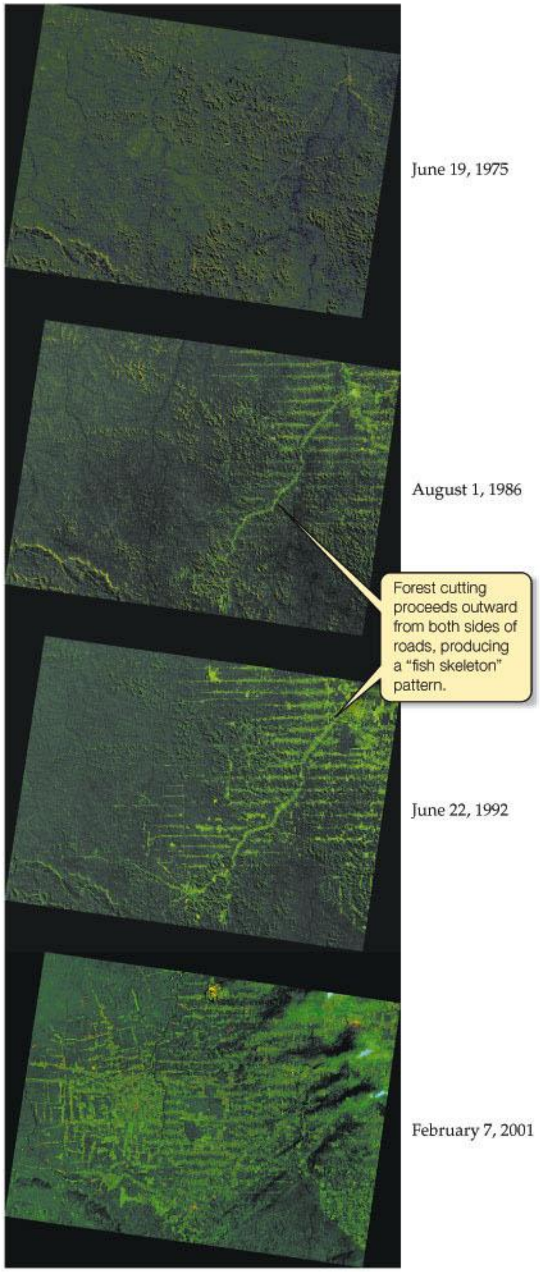


Satellite photos show rainforest clearing in Brazil, 1975-2001

ECOLOGY, Figure 3.6

Figure 3.6 Tropical Deforestation



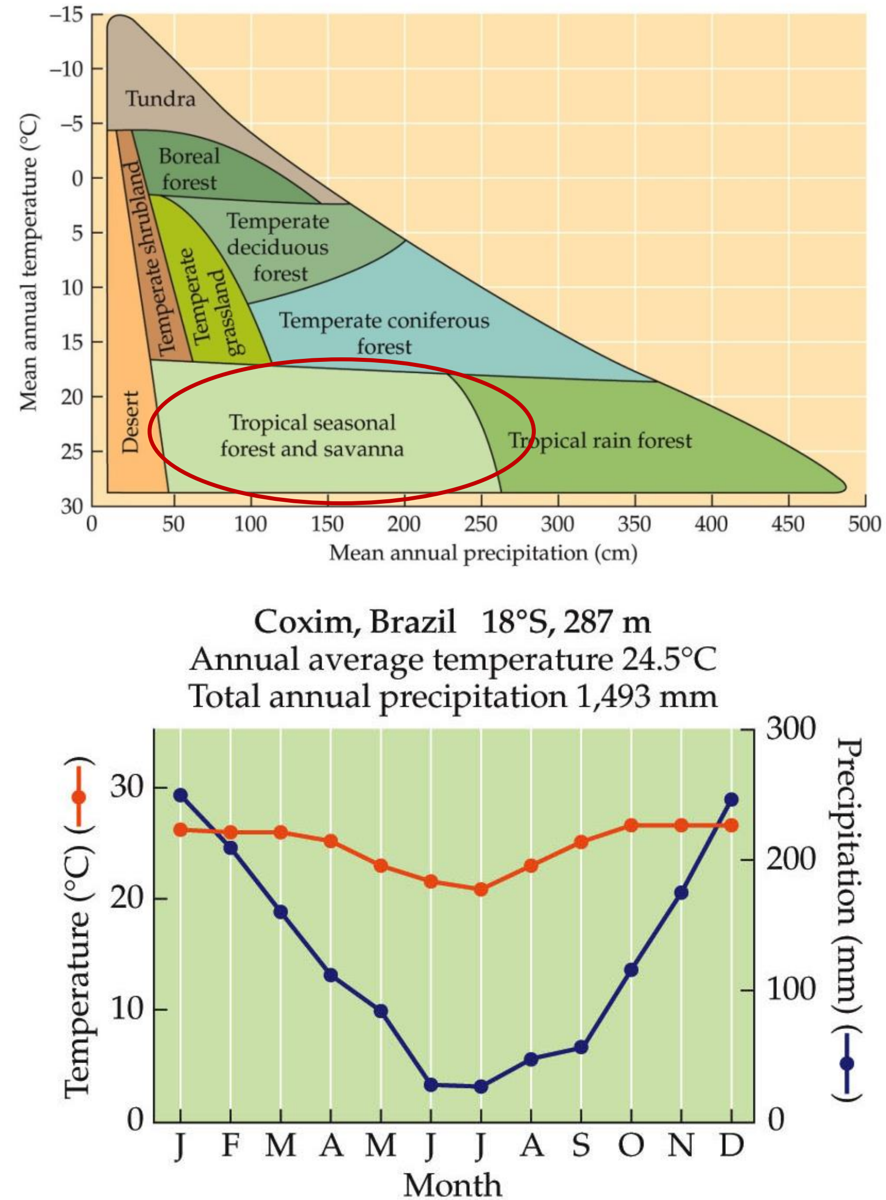


http://www.mongabay.com/images/rainforests/deforestation-in-the-amazon.jpg

***ECOLOGY,* Figure 3.6**

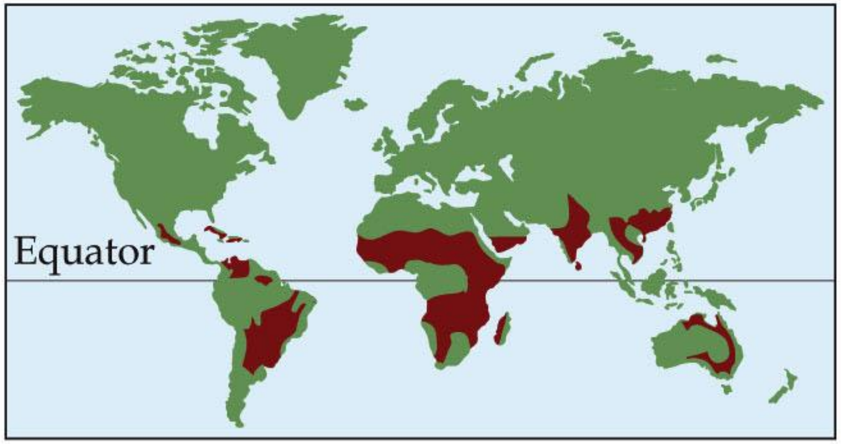
Tropical Seasonal (Dry) Forests and Savannas:

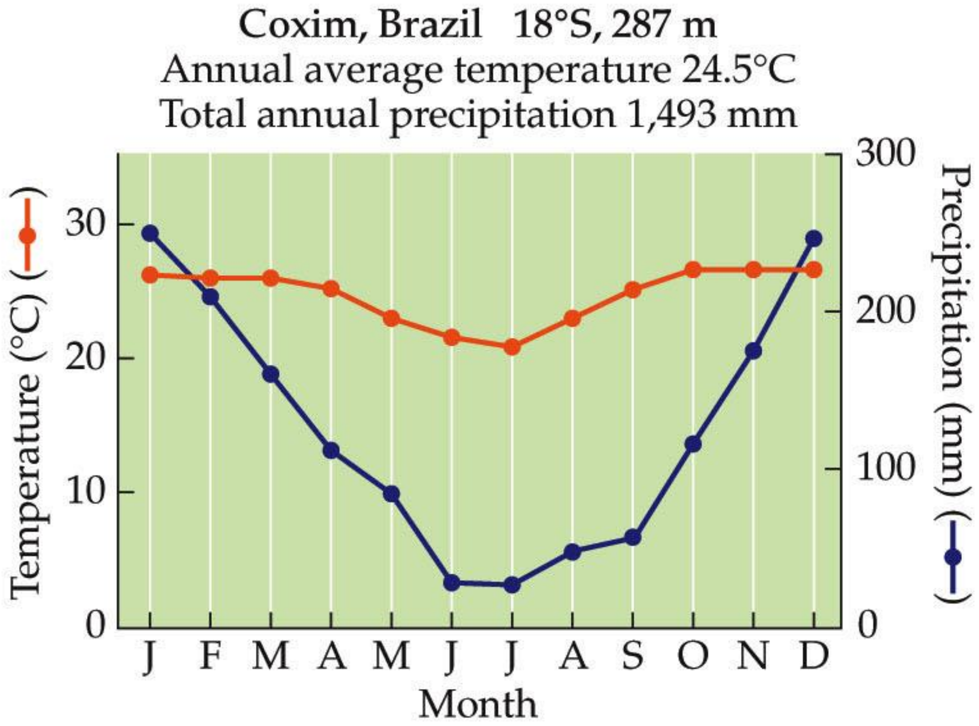
- From 10° to the Tropics of Capricorn (23.5°S) and Cancer (23.5°N).
- Wet and dry seasons associated with movement of the ITCZ.
- Shorter trees, deciduous in dry seasons, more grasses and shrubs.



***ECOLOGY*, Figure 3.B (Part 1)**

TROPICAL SEASONAL FORESTS AND SAVANNAS

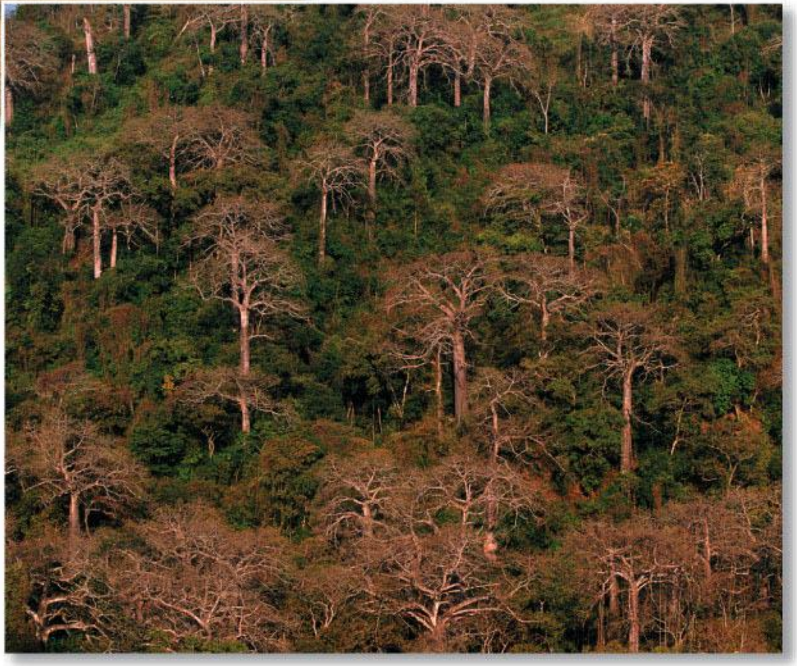




ECOLOGY, Figure 3.B (Part 1)

TROPICAL SEASONAL FORESTS AND SAVANNAS

Savanna in Natal, South Africa



Semi-evergreen forest including Pijio trees (*Cavanillesia platanifolia*), during the dry season, Cerro Blanco, Ecuador

ECOLOGY, Figure 3.B (Part 2)

Terrestrial Biomes

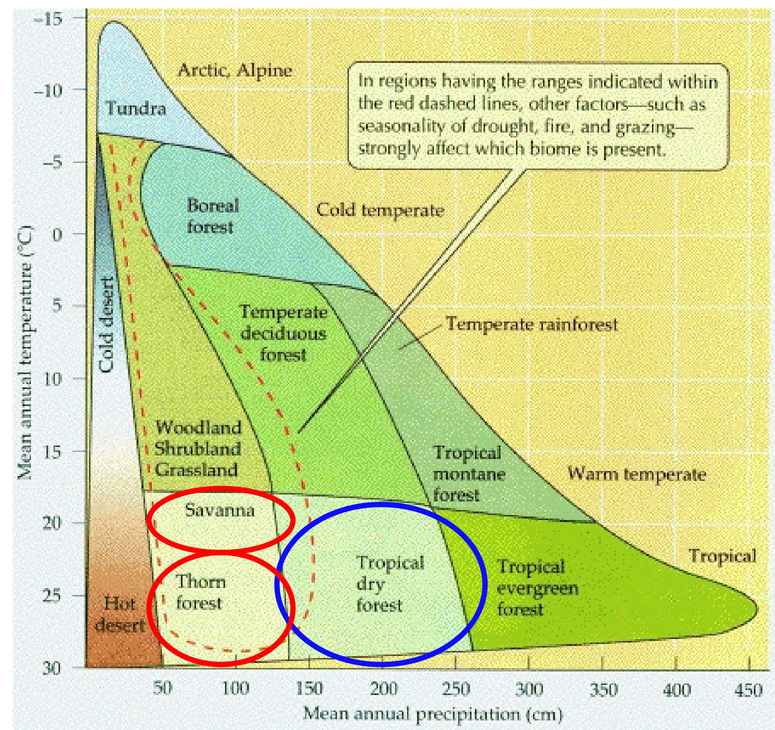
Tropical Seasonal Forests and Savannas include complex of tree-dominated systems:

- *Tropical dry forests* (wettest of the three)
- *Thorn woodlands* — trees have heavy thorns to protect from herbivores
- *Tropical savannas* — grasses with intermixed trees and shrubs

TROPICAL SEASONAL FORESTS AND SAVANNAS

Savanna in Natal, South Africa

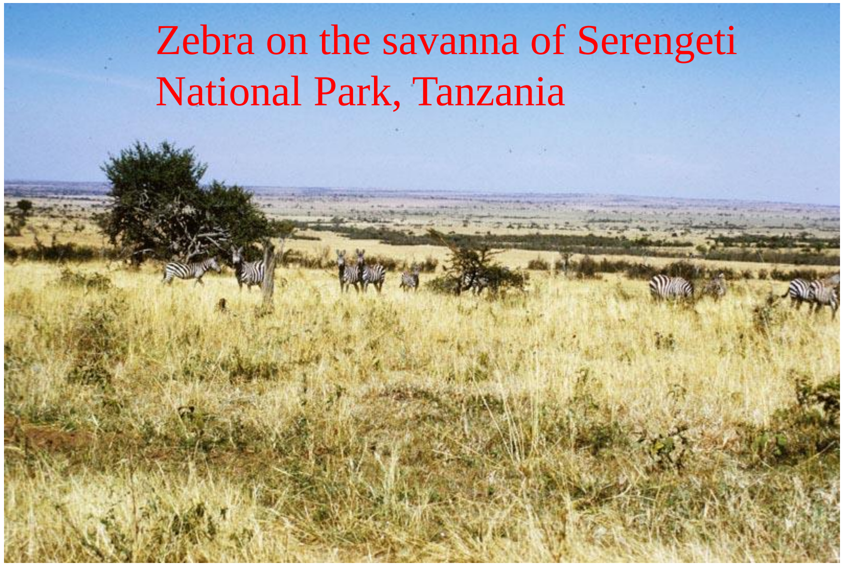
Semi-evergreen forest including Pijio trees (*Cavanillesia platanifolia*), during the dry season, Cerro Blanco, Ecuador



Terrestrial Biomes

- **Fires** promote establishment of savannas; some are set by humans.
- In Africa, *large herds of herbivores* — wildebeests, zebras, elephants, and antelopes (seasonal migrations) — also influence balance of grass and trees
- On Orinoco River floodplain, *seasonal flooding* promotes savannas

Orinoco River floodplain



Zebra on the savanna of Serengeti National Park, Tanzania

http://faculty.gg.uwyo.edu/heller/Sed%20Strat%20Class/Sedstrat4/Sedstrat4%20gifs/Apure%205.jpg

Terrestrial Biomes

Loss of seasonal tropical forests and savannas is equal to or greater than the loss of tropical rainforests.

- Human population growth in biome has had a major impact
- Large tracts have been converted to cropland and pasture

Dry forest habitat in the Tumbesian region, Peru

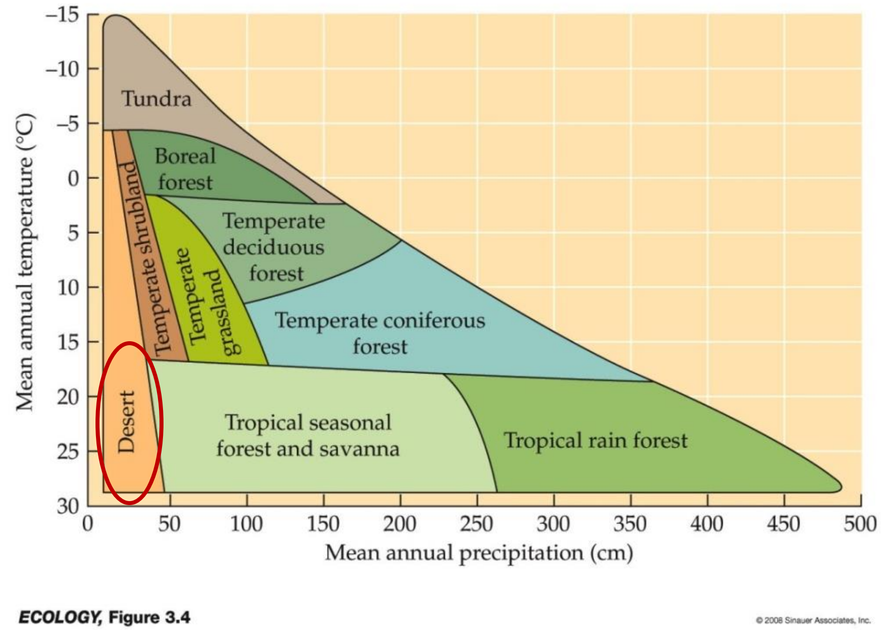
http://www.birdlife.org/images/sized/400/s_tumbesian_dry_forest.jpg.jpg

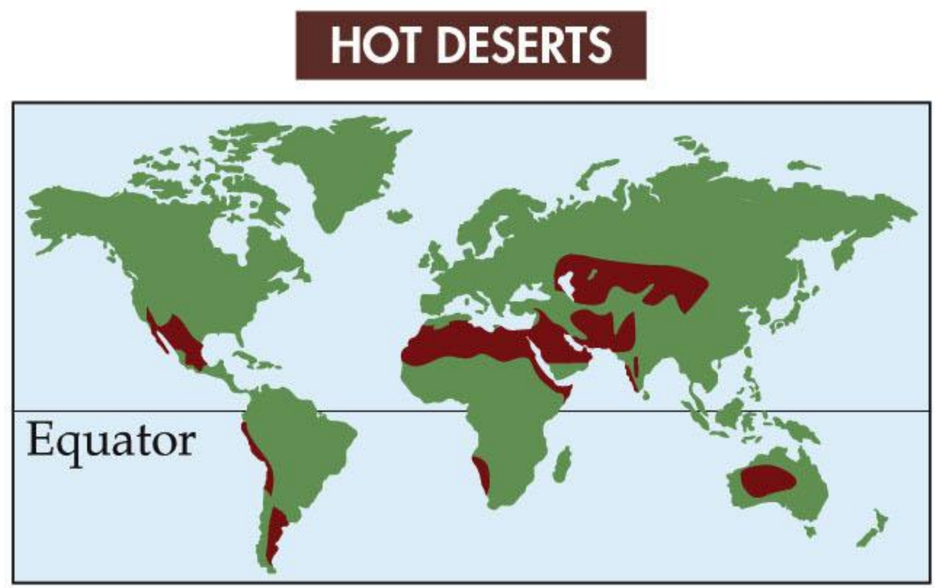
3.80 Clearing forest for agriculture, Guatemala

3.81 Clearcut forest in the Gishwati Preserve, Rwanda, for a World Bank-financed dairy project

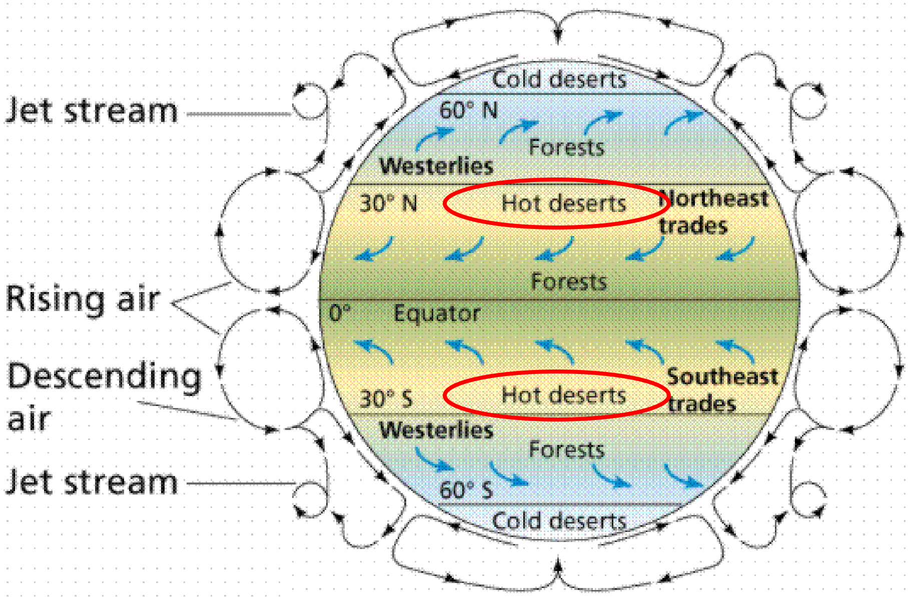
Hot Subtropical Deserts:

- Associated with high pressure zones around 30° N and S
- High temperatures, low water availability
- Sparse vegetation and animal populations
- Many plants exhibit stem succulence — cacti in the Western Hemisphere, euphorbs in the Eastern Hemisphere

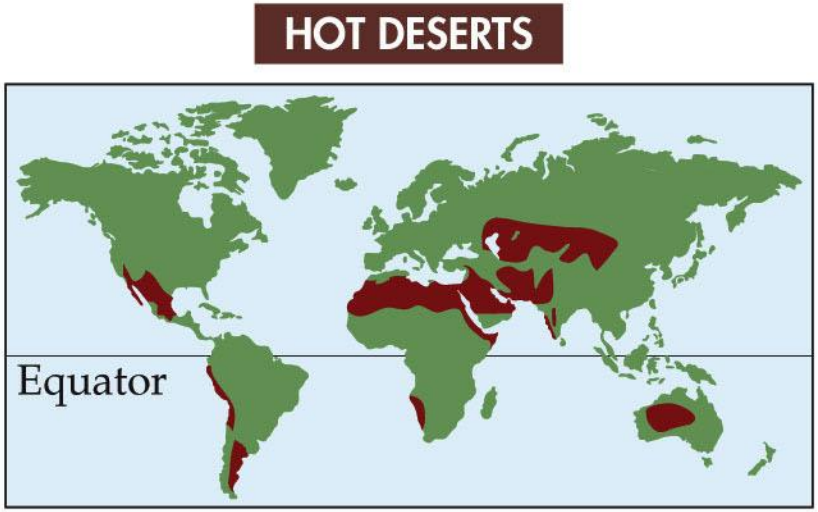


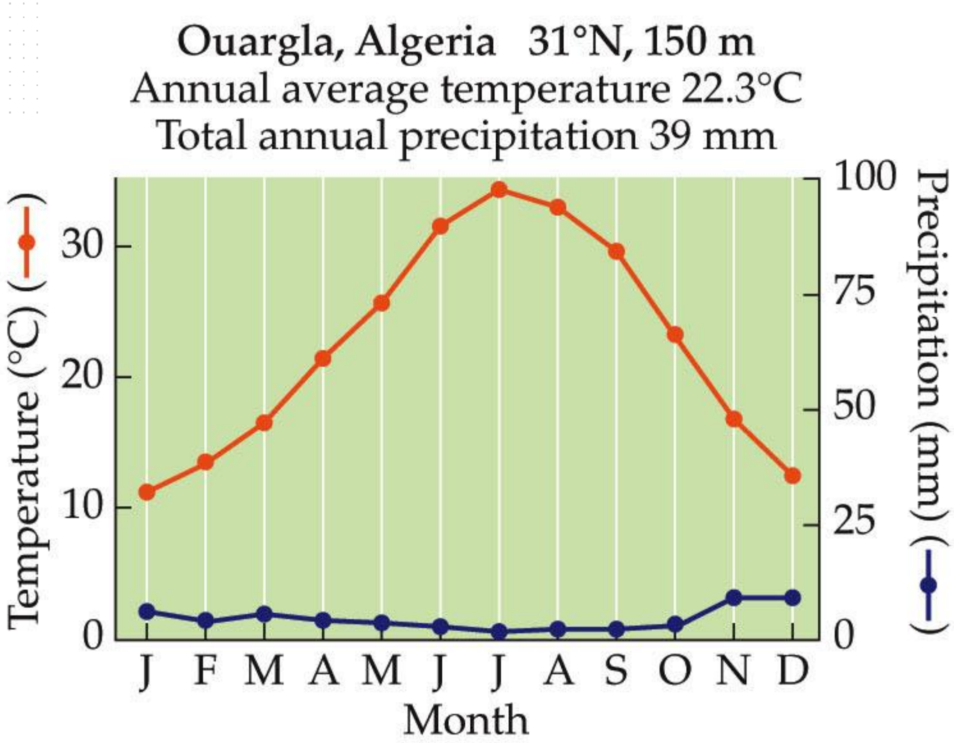


http://www.globalchange.umich.edu/globalchange2/current/2007/Labs/Unit%203b2007_files/image005.gif



Associated with high pressure zones around 30° N and S





ECOLOGY, Figure 3.C (Part 1)

Plants with succulent stems can store water in their tissues

- Desert plants also include drought-deciduous shrubs, grasses, and short-lived annual plants that are active only after a rain
- Abundance may be low but species diversity can be high

HOT DESERTS

Palm trees growing out of sand, Oasis Dakhia, Sahara Desert, Egypt

Sonoran desert in bloom, Ajo Mountains, Organ Pipe National Monument, Arizona

ECOLOGY, **Figure 3.C (Part 2)**

3.50 Wildflower display brought about by a seasonal rainstorm in the Arizona desert

HOT DESERTS

Palm trees growing out of sand, Oasis Dakhia, Sahara Desert, Egypt

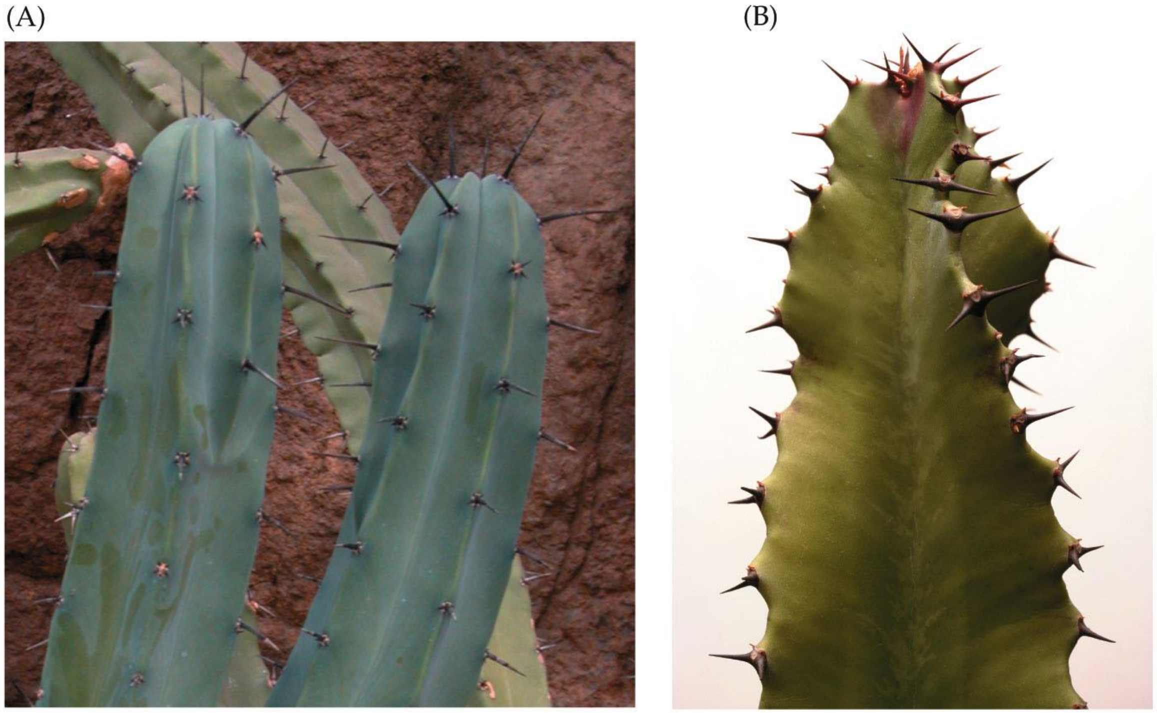
Sonoran desert in bloom, Ajo Mountains, Organ Pipe National Monument, Arizona

Convergence of characters in desert plants

- Spines
- Succulence
- CAM photosynthesis
- Upright stems to miminize sun exposure

(A) Blue candle cactus from Chihuahuan desert of Mexico

(B) Candelabra plant native to deserts of Asia and India.



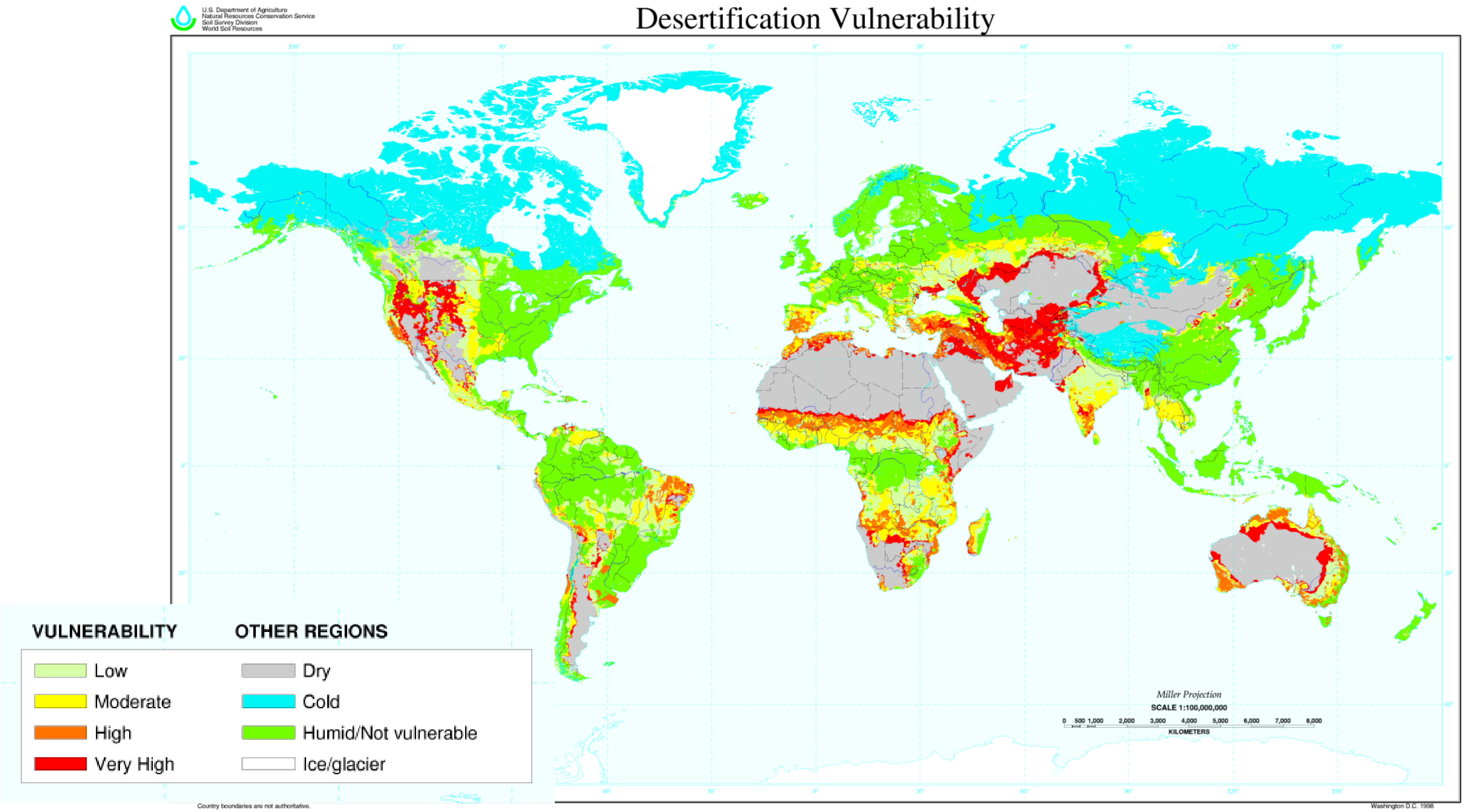
ECOLOGY, Figure 3.7

Humans have used deserts for agriculture and livestock grazing

- Agriculture depends on irrigation, and results in soil **salinization**
- Long-term droughts in association with unsustainable grazing can result in **desertification** — loss of plant cover and soil erosion

http://www.kennecottminerals.com/00_00006_2.jpg

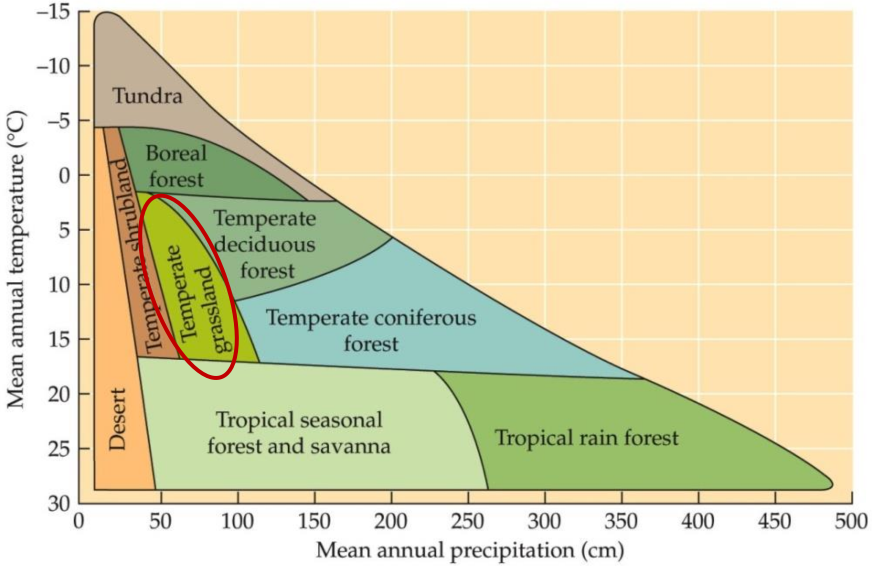
The Desertification Vulnerability map is based on a reclassification of the global soil climate map and global soil map by the Dept. of Agriculture. It shows global distribution of desertification vulnerability



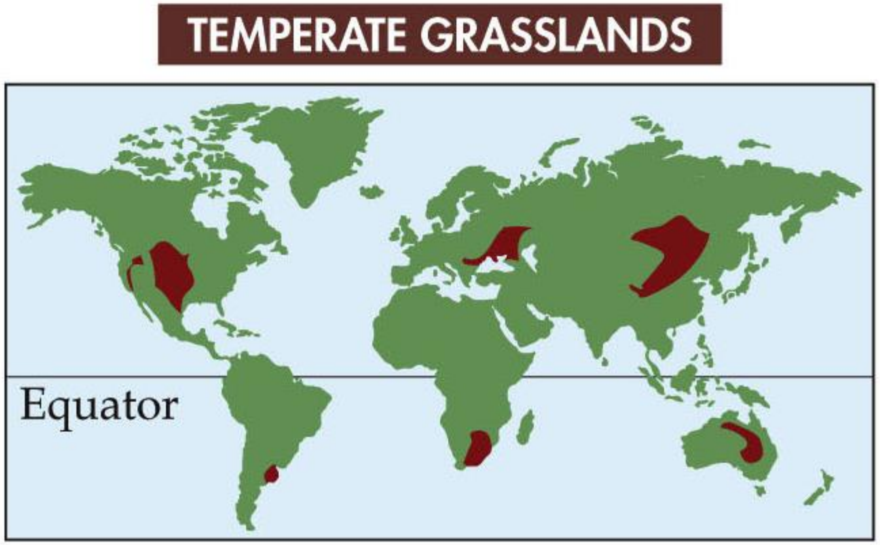
http://upload.wikimedia.org/wikipedia/commons/6/68/Desertification_map.png

Temperate Grasslands:

- Between 30° and 50° latitude
- Grasses dominate – maintained by frequent fires and large herbivores such as bison

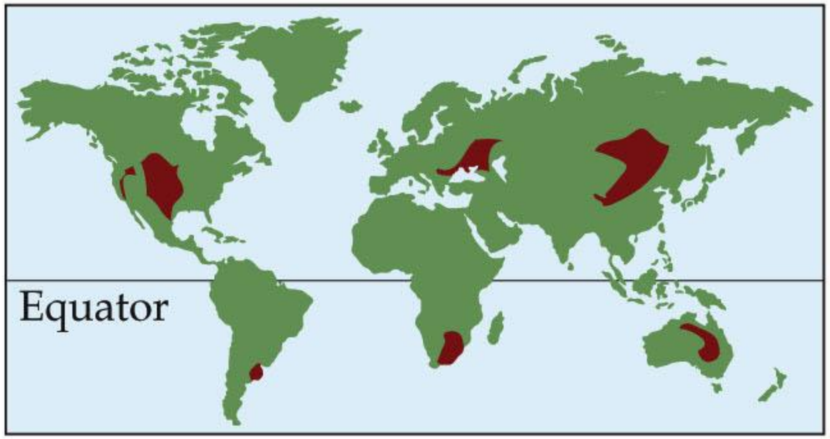


***ECOLOGY*, Figure 3.4**

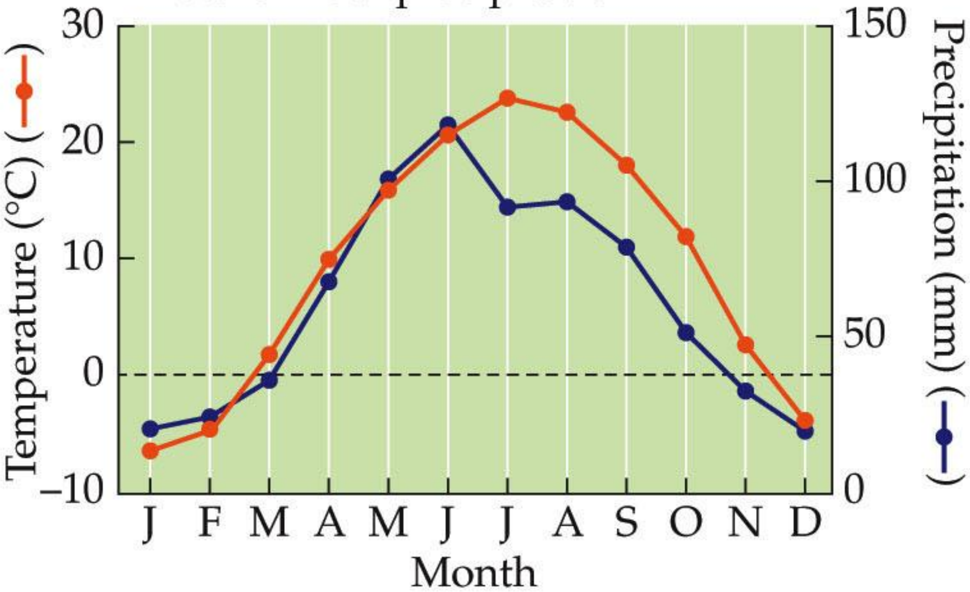


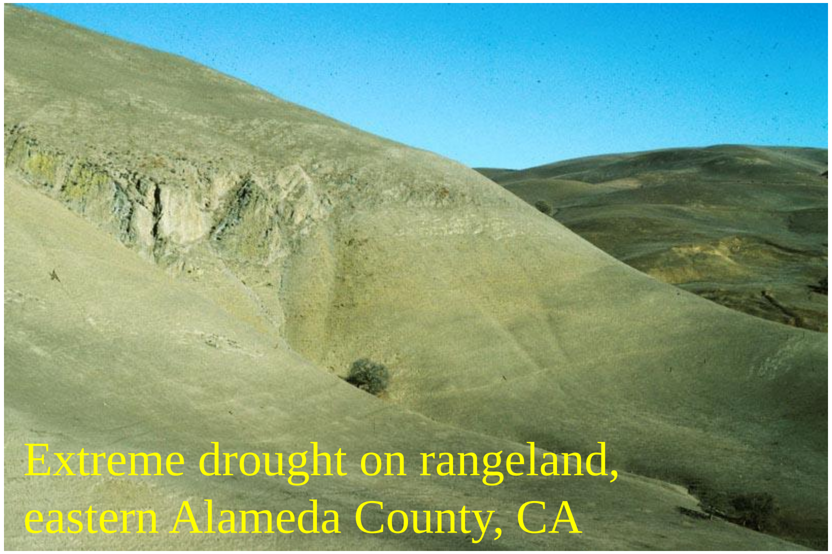
- Seasonal temperature variation — warm, moist summers and cold, dry winters

TEMPERATE GRASSLANDS



Denison, Nebraska, USA 41°N, 389 m
Annual average temperature 9.1°C
Total annual precipitation 727 mm





ECOLOGY, Figure 3.D (Part 1)

TEMPERATE GRASSLANDS

Western edge of the Great Plains, Arapaho National Wildlife Refuge, Colorado

Grassland with camomile flowers, Altai Plateau, Russia

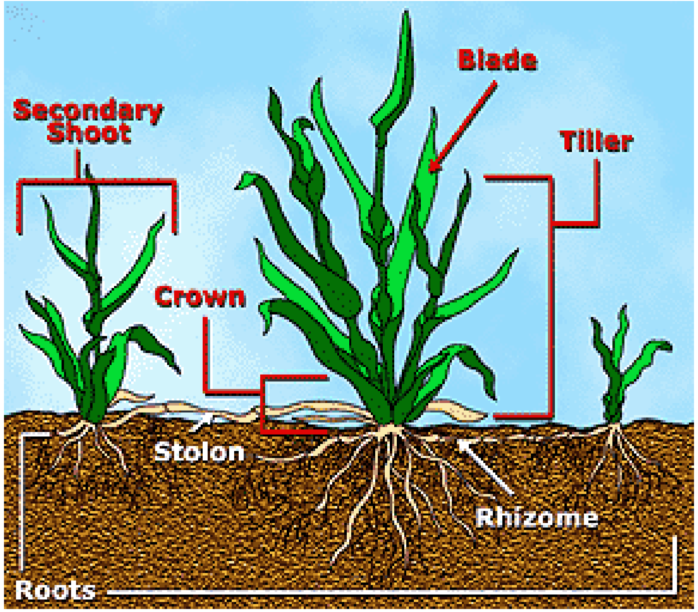
ECOLOGY, **Figure 3.D (Part 2)**

http://images.lowes.com/general/g/grassanatomy2.gif

Terrestrial Biomes

Grasses grow more roots than stems and leaves, to cope with dry conditions

- Results in accumulation of organic matter and high soil fertility
- Most fertile grasslands of central North America and Eurasia have been converted to agriculture



http://www.nebraskatravels.com/images-western-ne-road-trip/western-nebraska-sandhills-travel-cattle-by-windmill-fence-640w-1352cet-70.jpg

Terrestrial Biomes

In more arid grasslands, grazing by domesticated animals can exceed capacity for regrowth

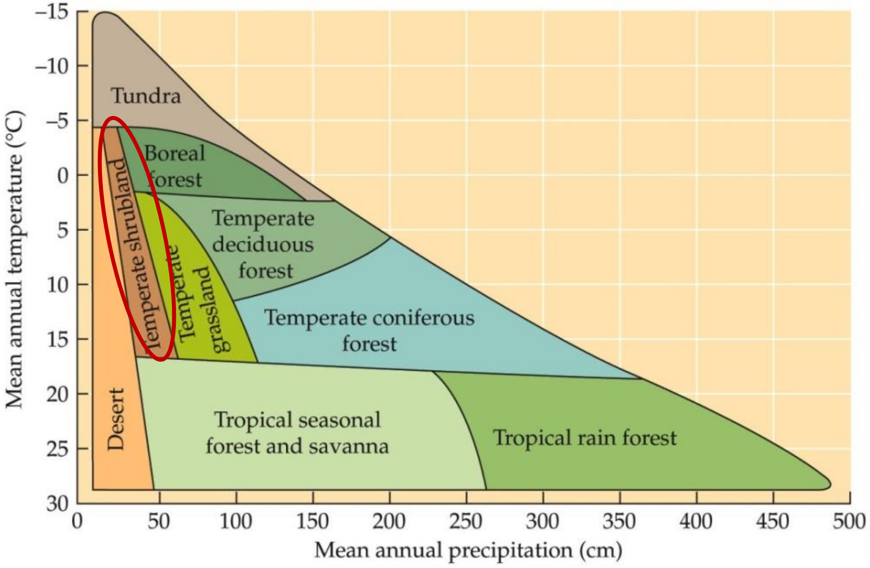
- leads to grassland degradation, and desertification
- Irrigation of some grassland soils has resulted in salinization

The dust bowl of the Great Plains in the 1930s was due to severe drought on the heels of decades of poor farming practices (no crop rotation or erosion control)

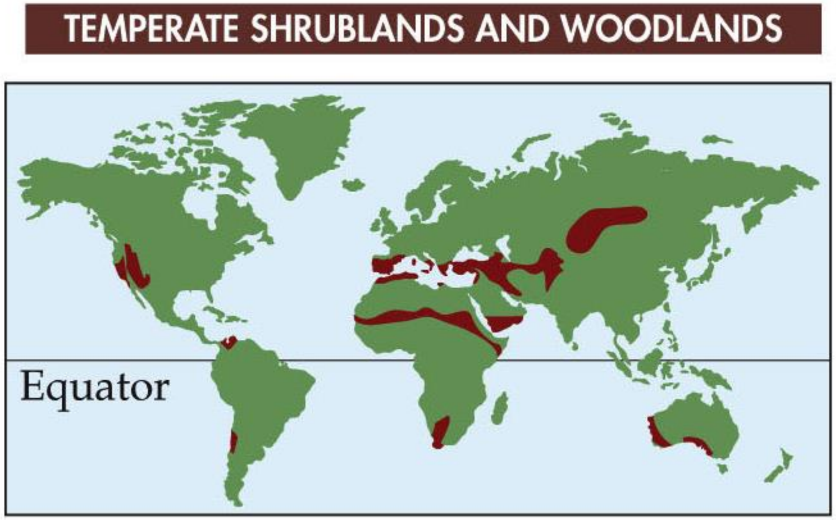
http://static.howstuffworks.com/gif/us-desert-50-years-2.jpg

Temperate Shrublands and Woodlands:

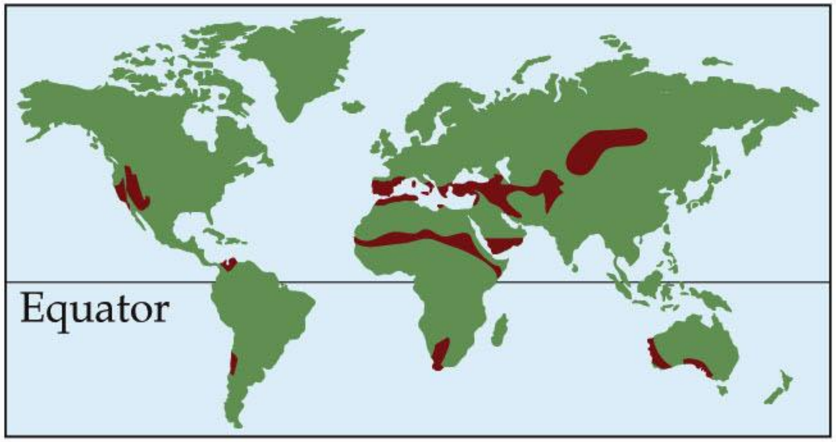
- Wet season in winter; hot, dry summers
- *Mediterranean-type climates* — west coasts of the Americas, Africa, Australia, and Europe, between 30°–40° N and S.
- Vegetation is evergreen shrubs and trees
- Fire is a common feature



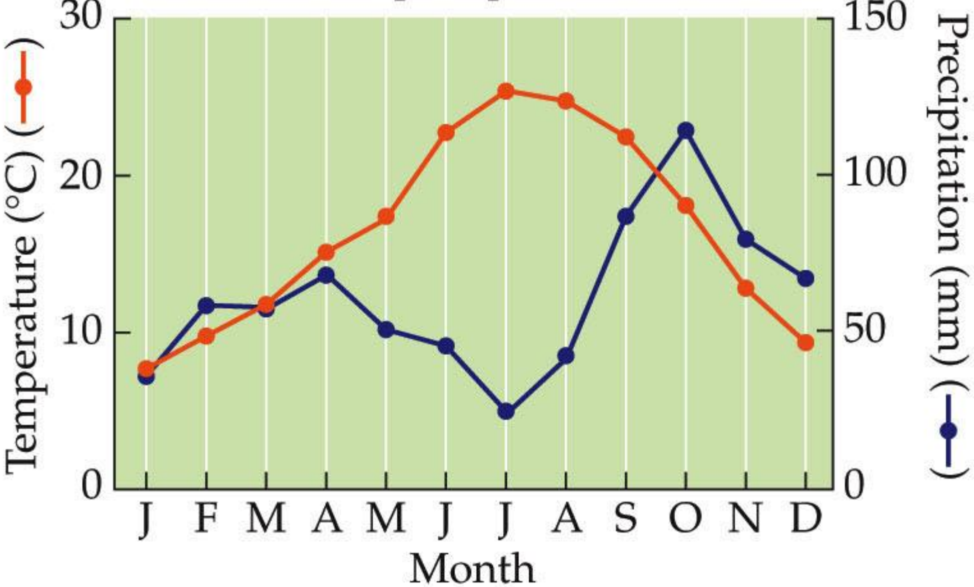
ECOLOGY, Figure 3.4



TEMPERATE SHRUBLANDS AND WOODLANDS



Gerona, Spain 41°N, 76 m
Annual average temperature 16.7°C
Total annual precipitation 747 mm



ECOLOGY, **Figure 3.E (Part 1)**

TEMPERATE SHRUBLANDS AND WOODLANDS

Maquis shrubland, Mediterranean coast, Majorca, Spain

Fynbos landscape with everlastings (*Helichrysum* sp.), Kogelberg Nature Reserve, South Africa

ECOLOGY, **Figure 3.E (Part 2)**

Evergreen leaves allow plants to be active during cooler, wetter periods

- Also lowers nutrient requirements — they do not have to develop new leaves every year like deciduous trees
- **Sclerophyllous** leaves — tough and leathery — deter herbivores and prevent wilting

http://wync.typepad.com/wync/images/creosote2.jpg

Terrestrial Biomes

http://www.thegreatsitting.com/mikejournal/archives/Great-Basin.jpg

Mediterranean-type zones include…

- the *mallee* of Australia,
- the *fynbos* of South Africa,
- the *matorral* of Chile,
- the *maquis* around the Mediterranean Sea, and
- the ***chaparral*** of North America

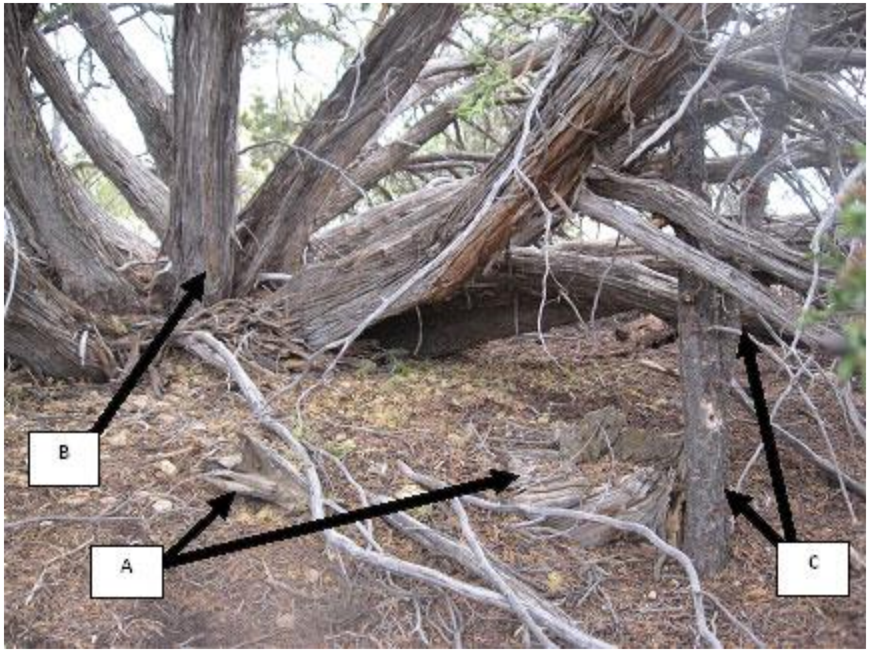
Chaparral biome in Monterrey, CA

3.63 Chaparral biome in Monterrey, CA

Fires may contribute to the persistence of these biomes

- After fires, some shrubs sprout from underground storage organs, others produce seeds that sprout and grow quickly after fire
- Without regular fires at 30–40-year intervals, some shrublands may be replaced by forests.

This image shows (A) coarse wood left after a fire that probably occurred before 1900, (B) a juniper tree that has established and grown since the fire, and (C) younger pinyon pine trees that have established beneath the older juniper.

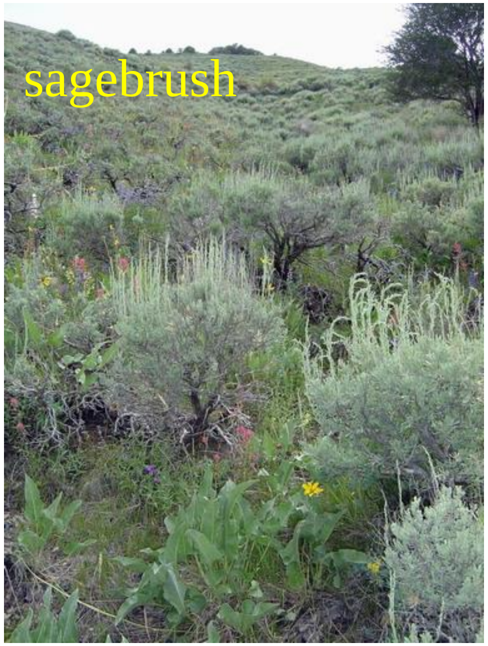


http://www.eri.nau.edu/joomla/content/view/238/92/

Terrestrial Biomes

Shrublands are also found in continental interiors

- associated with rain shadows and seasonally cold climates
- An example is the Great Basin between the Sierra Nevada and Cascade Mountains, with large expanses of sagebrush, saltbush, creosote bush, and piñon pine and juniper woodland



http://geochange.er.usgs.gov/sw/impacts/biology/pastclim/f15_jun_art.jpeg

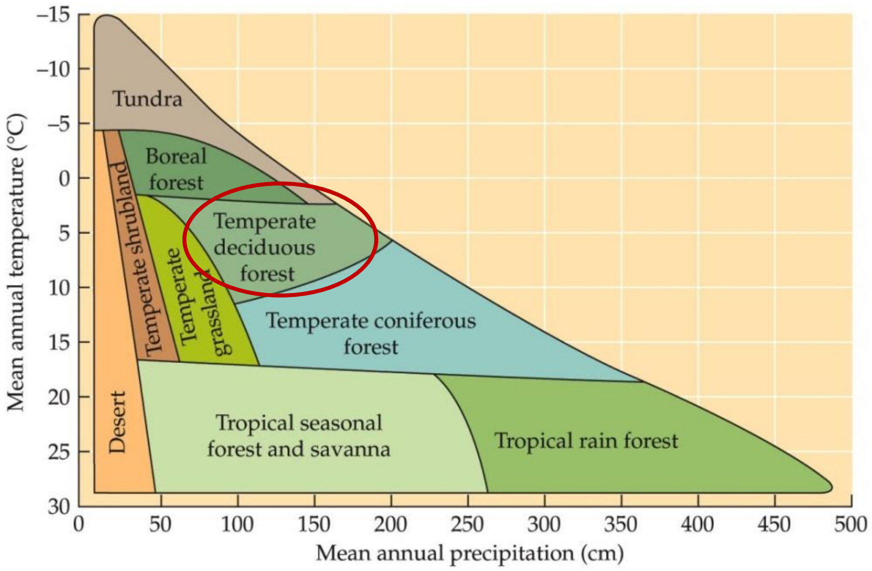
Some temperate shrublands have been converted to crops and vineyards, but the soils are nutrient-poor

- Urban development has reduced the biome in some areas, such as southern California.
- Increased fire frequency reduces the ability of the vegetation to recover, and invasive grasses can move in

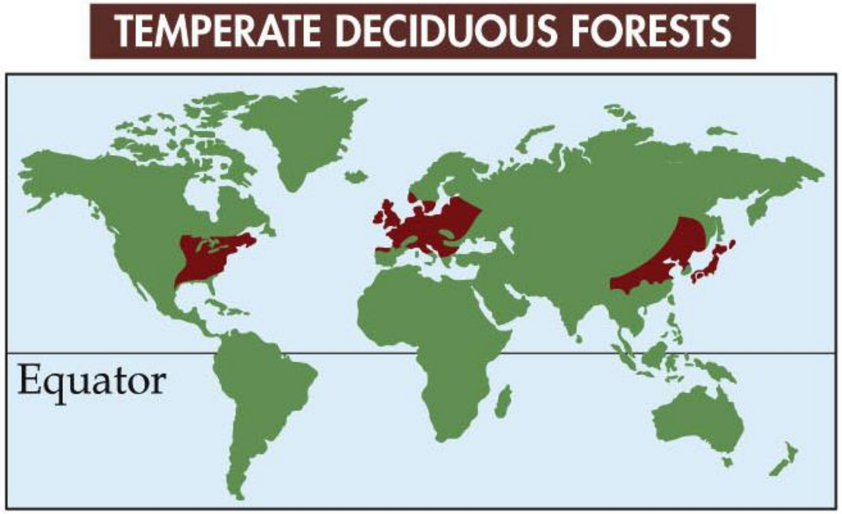
http://www.nwhi.org/pix/Hab_desc/H19_3.jpg

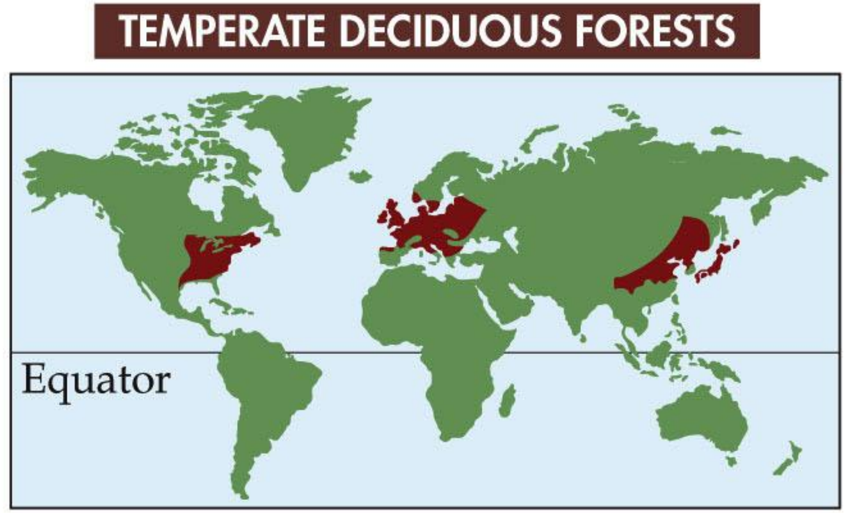
Temperate Deciduous Forests:

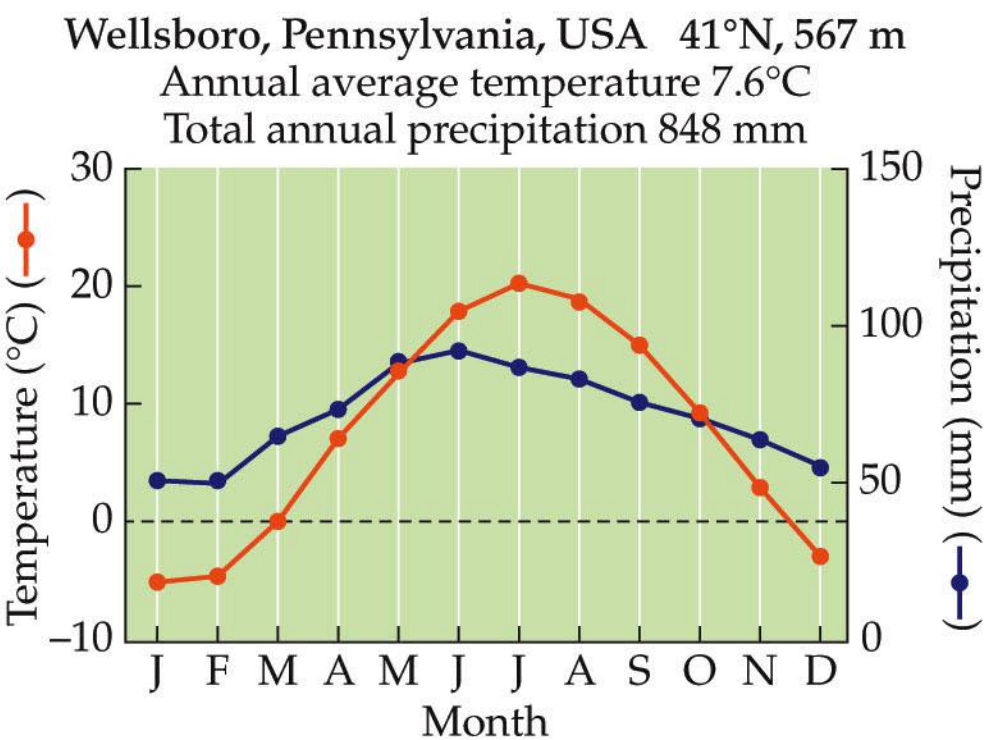
- Occur at 30° to 50° N, on continental edges, in areas with rainfall to support tree growth
- Leaves are dropped during winter
- Oaks, maples, and beeches occur everywhere in this biome
- Species diversity lower than tropical rainforests



ECOLOGY, Figure 3.4



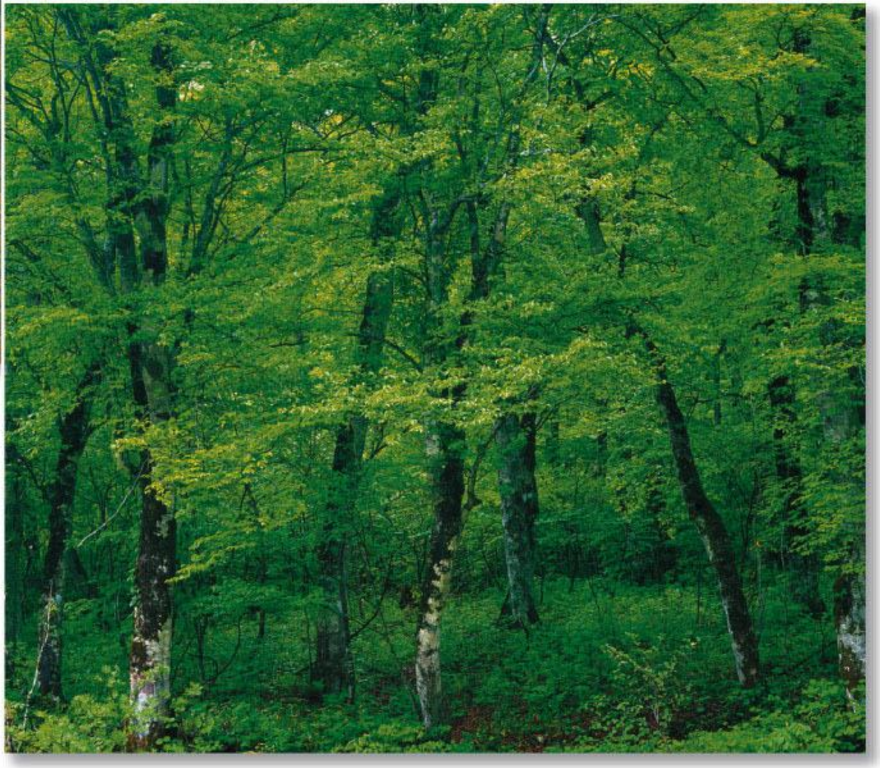




ECOLOGY, Figure 3.F (Part 1)

TEMPERATE DECIDUOUS FORESTS

Autumn foliage prior to leaf fall, Great Smoky Mountains, Tennessee



Beech forest in summer, Japan

ECOLOGY, **Figure 3.F (Part 2)**

Soils are fertile and agriculture has been a focus for centuries

- Very little old-growth temperate forest remains.
- As agriculture shifts to tropics, temperate forests have regrown, with shifts in species composition
- Species shifts are due to nutrient depletion by agriculture and invasives such as the chestnut blight

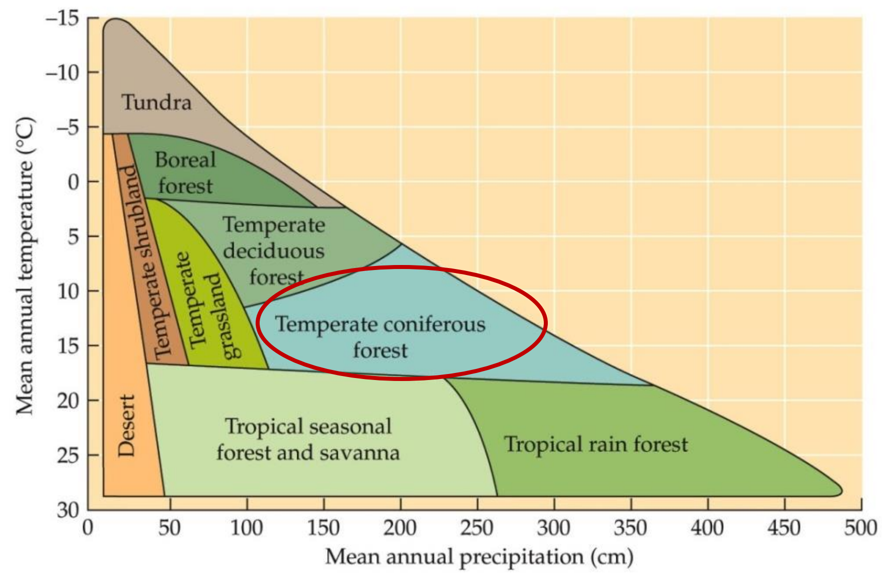
http://www.atexperience.com/photos/massachusetts/large/July%2030%20-%20Farmland.jpg

3.56 Stream in Rhode Island

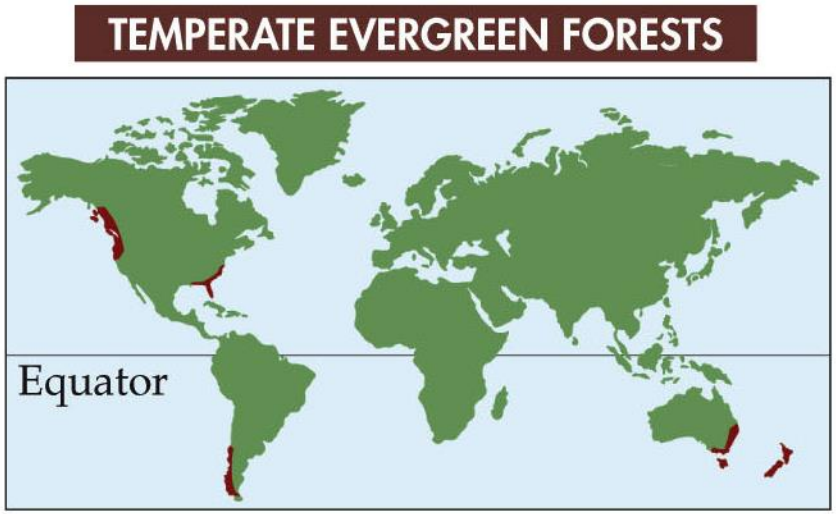
Terrestrial Biomes

Temperate Evergreen Forests:

- At 30° to 50° N and S, in coastal and maritime zones
- Lower diversity than tropical and deciduous forests
- Leaves tend to be acidic, and soils nutrient-poor
- Temperate rainforests receive 50–400 cm rain per year

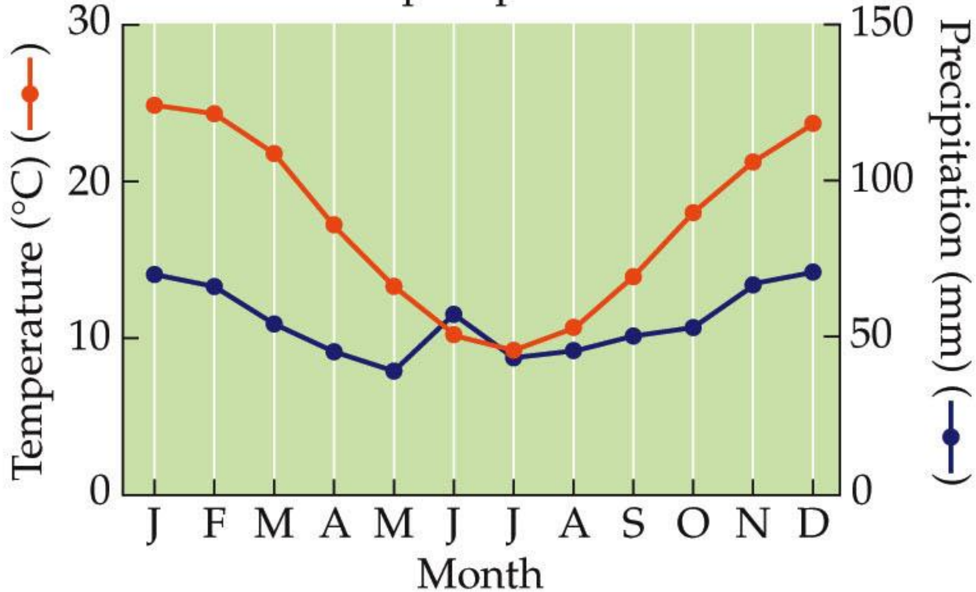


ECOLOGY, Figure 3.4



TEMPERATE EVERGREEN FORESTS

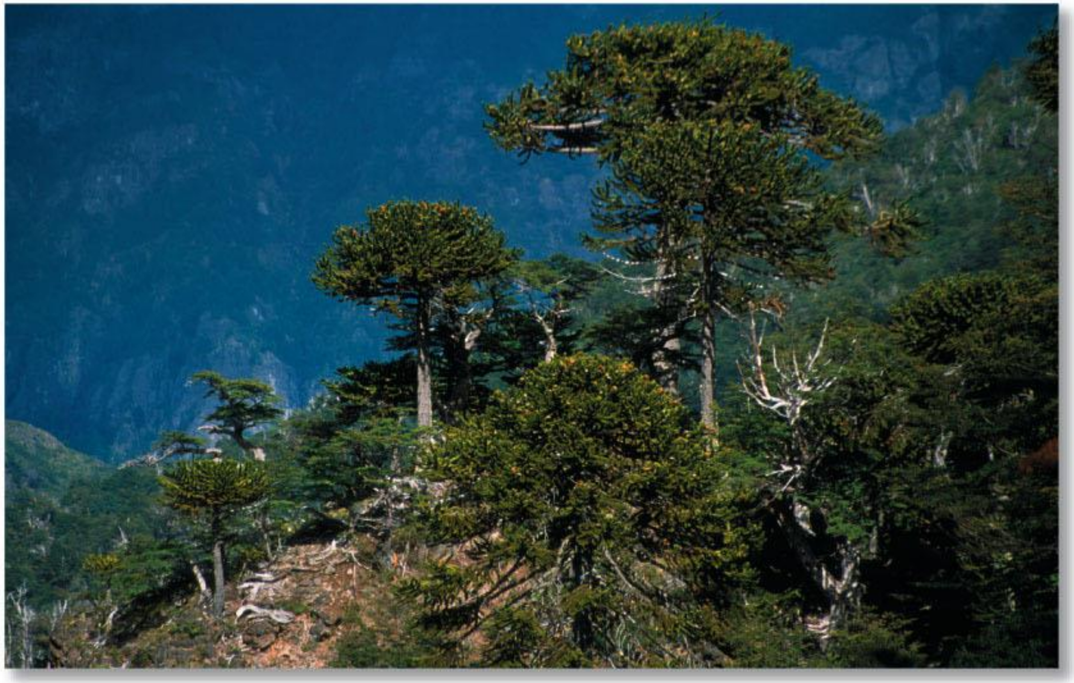
Tamworth, Australia 31°S, 405 m
Annual average temperature 17.5°C
Total annual precipitation 672 mm



***ECOLOGY,* Figure 3.G (Part 1)**

TEMPERATE EVERGREEN FORESTS

Grove of giant sequoias, *Sequoiadendron giganteum*, with douglas fir (*Pseudotsuga menziesii*), Mariposa Grove, Yosemite National Park, California



Araucaria (monkey puzzle tree) forest, Lanin National Park, Argentina

ECOLOGY, Figure 3.G (Part 2)

Figure 3.8 Temperate Rainforest in Tasmania

3.75 Clearcut of coastal old-growth forest, Olympic Peninsula, WA

Evergreen trees are used for wood and paper pulp, thus this biome has been logged extensively.

- Very little old-growth temperate evergreen forest remains.
- In some areas, planting of non-native species and uniformly aged stands has resulted in very different ecological conditions.

Longleaf pine-saw palmetto forest, Florida

http://i.treehugger.com/images/2007/10/24/longleafpine.gif

Suppression of fires has increased density of forest stands, which results in more intense fires when they do occur

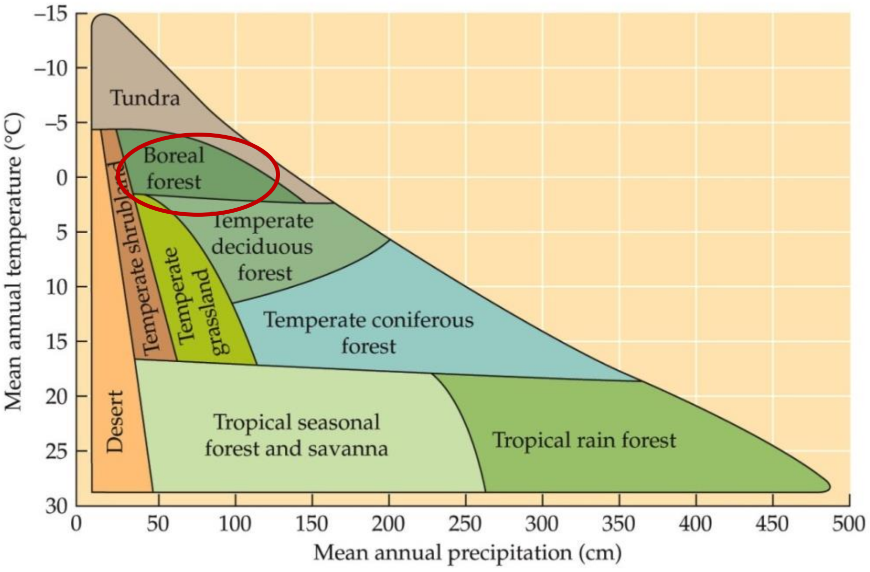
- It also increases the spread of insect pests and pathogens
- Air pollution has damaged some temperate evergreen forests
- Prescribed burns helps to reverse these problems

Prescribed fire set in longleaf forest in Florida

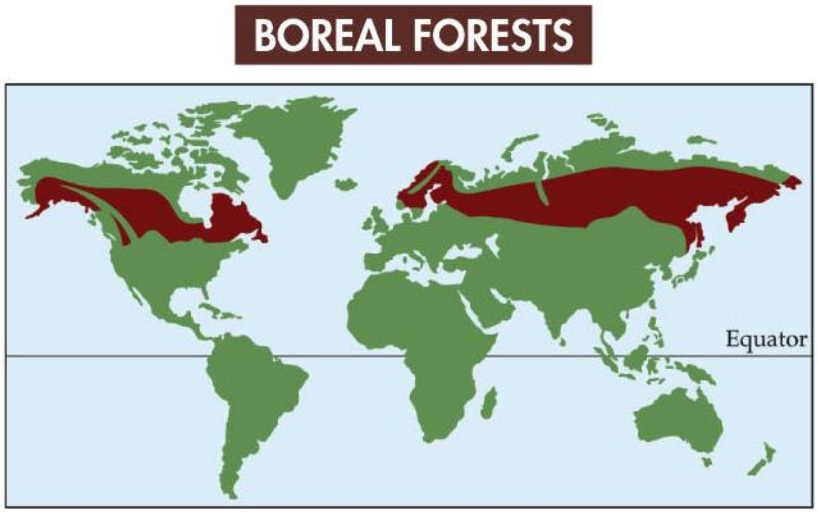
http://www.nwrc.usgs.gov/factshts/018-00/018-00.htm

Boreal Forests (Taiga):

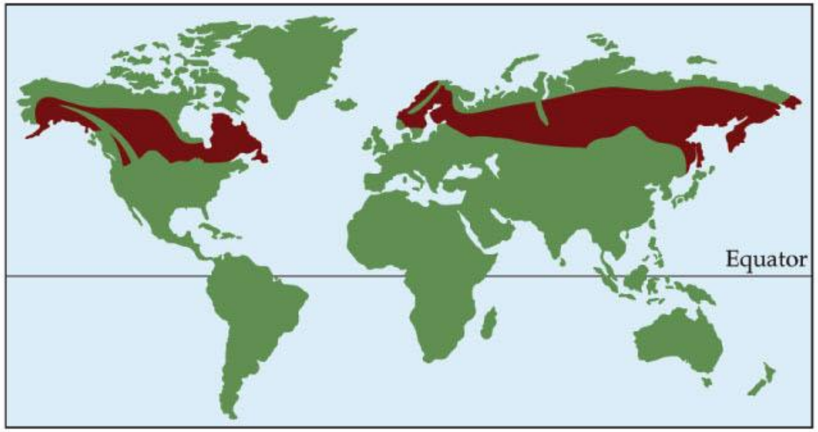
- Between 50° and 65° N
- Long, severe winters
- **Permafrost** (subsurface soil that remains frozen year-round) impedes drainage and causes soils to be saturated
- Trees are conifers — pines, spruces, larches

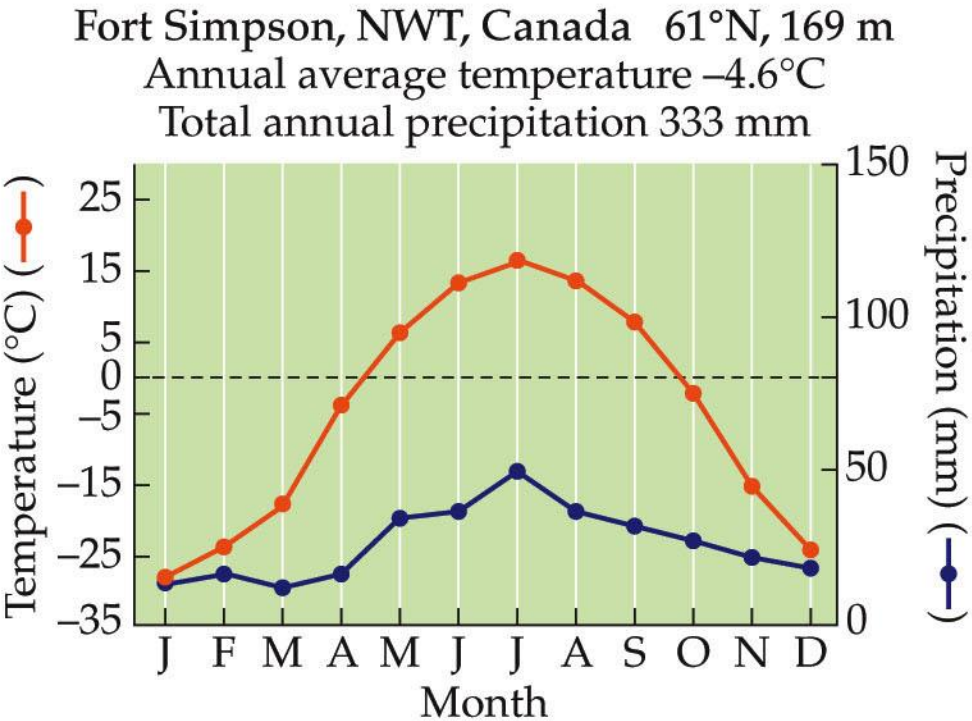


ECOLOGY, Figure 3.4



BOREAL FORESTS





***ECOLOGY*, Figure 3.H (Part 1)**

BOREAL FORESTS

Spruce trees on the margin of a bog in autumn, Denali National Park, Alaska

Boreal forest landscape, Canadian shield, northern Quebec

Cold, wet conditions in boreal soils limits decomposition, so soils have high organic matter

- In summer droughts, forest fires can be set by lightning, and burn both trees and soil
- In low-lying areas, extensive peat bogs form

Peat bogs in discontinuous permafrost, Manitoba.

http://gsc.nrcan.gc.ca/landscapes/details_e.php?photoID=537

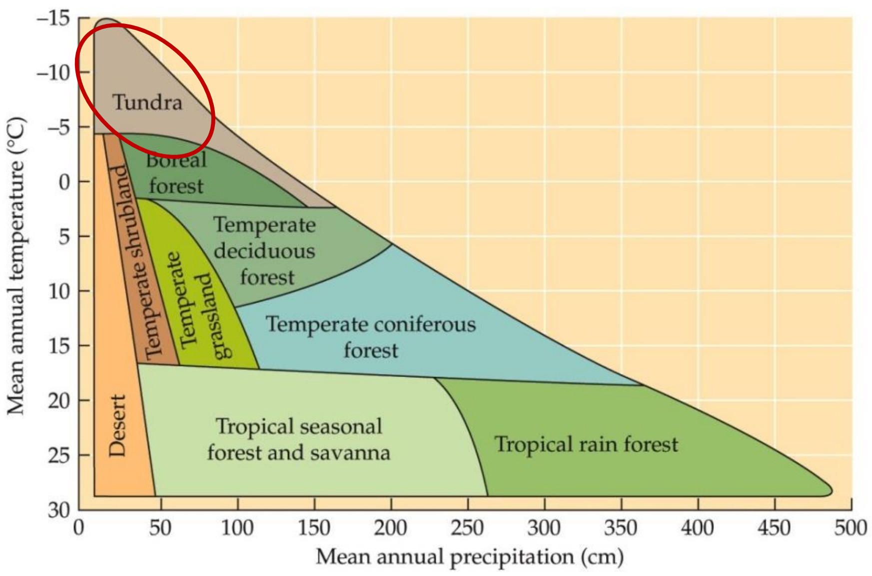
ECOLOGY, Figure 3.9

Boreal forests have not been as affected by human activities

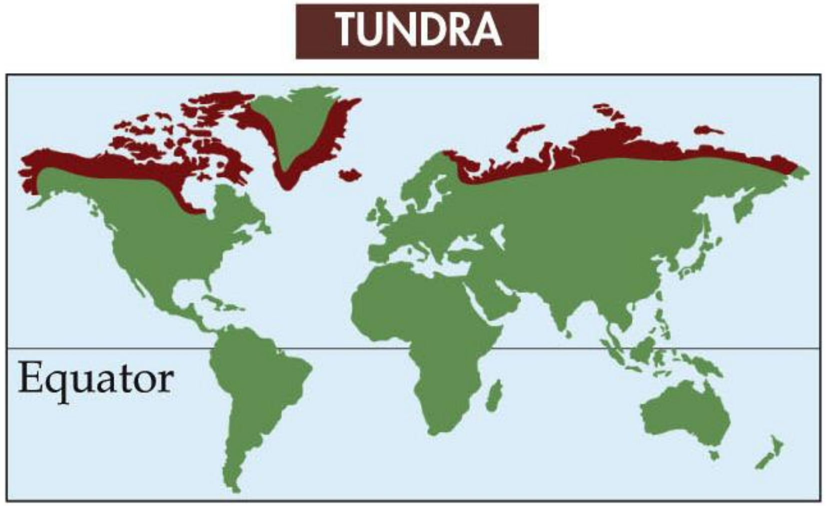
- Logging, and oil and gas development, occur in some regions – impacts will increase as energy demands increase
- Climate warming may result in release of carbon stored in boreal soils, creating a positive feedback to warming.

Tundra:

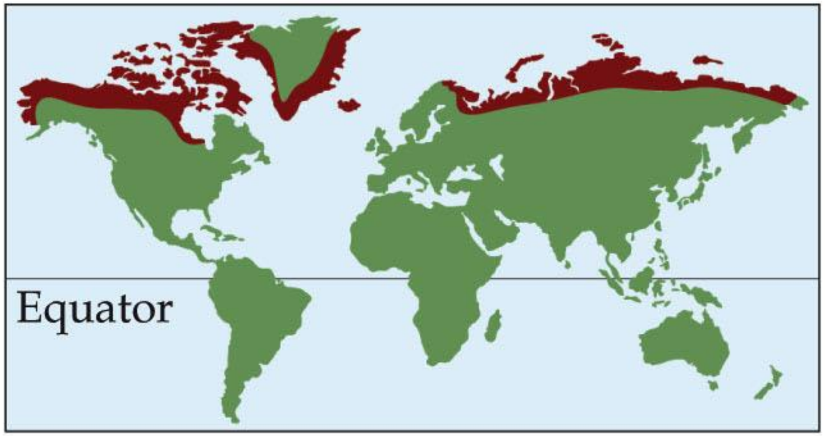
- Above 65° latitude, mostly in the Arctic
- Cold temperatures, low precipitation
- Short summer with long days
- Vegetation is sedges, forbs, grasses, low-growing shrubs, lichens, and mosses
- Permafrost is widespread



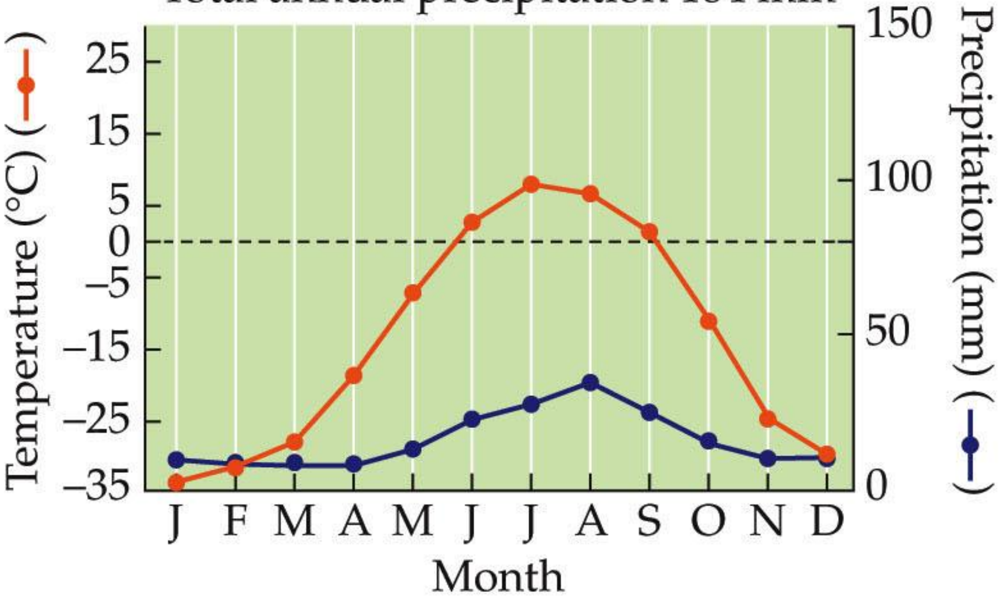
ECOLOGY, Figure 3.4



TUNDRA



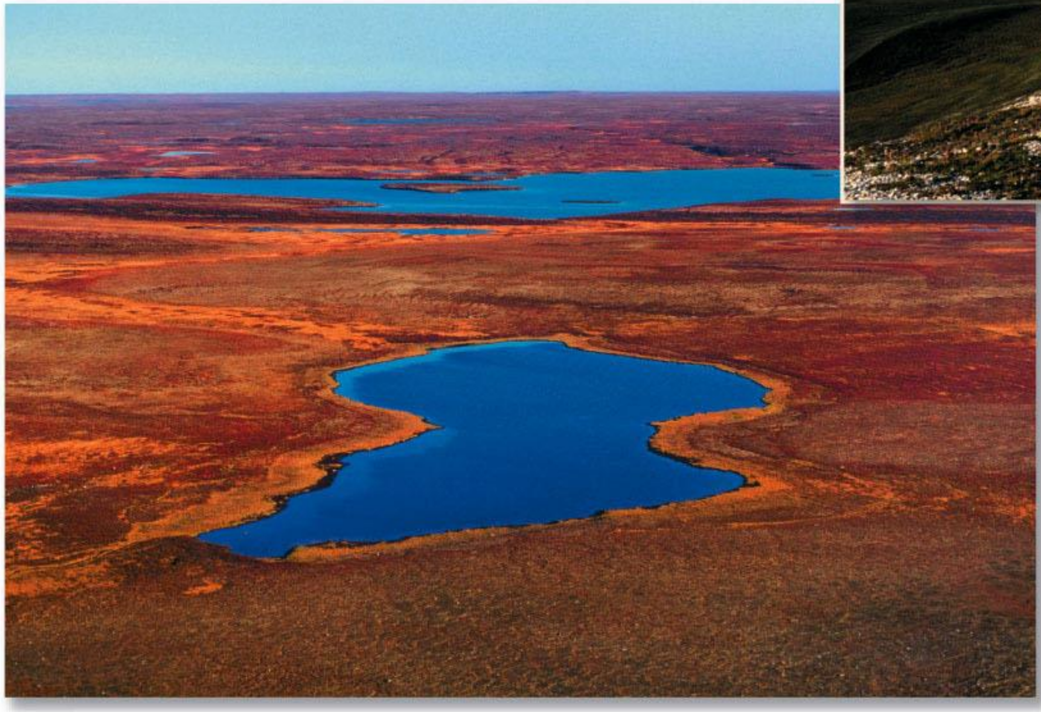
Olenek, Russia 73°N, 11 m
Annual average temperature –14.3°C
Total annual precipitation 184 mm



***ECOLOGY,* Figure 3.I (Part 1)**

TUNDRA

Looking out to the Arctic plain at midnight from the northern edge of the Brooks Range, Alaska



Arctic tundra of Thelon barrenlands in early autumn color, Northwest Territories, Canada

Repeated freezing and thawing of surface soil layers results in sorting of soil materials according to texture

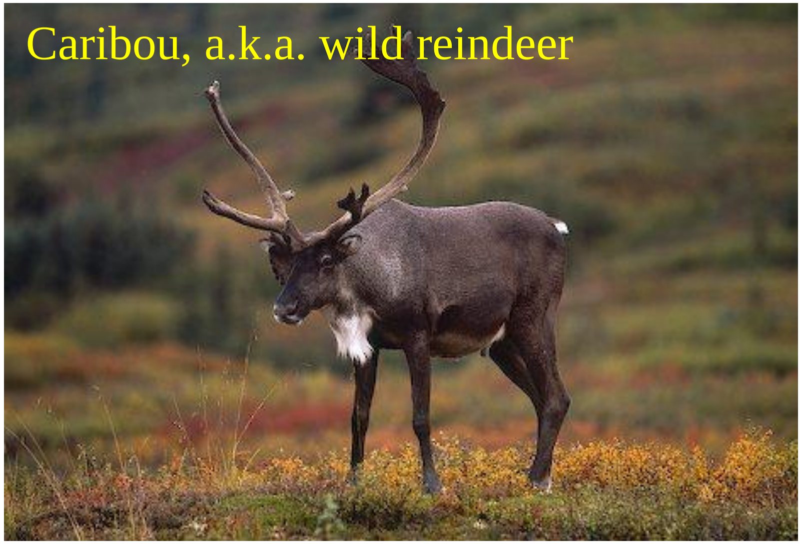
- Polygons of soil form at the surface, with upraised rims and depressed centers

ECOLOGY, Figure 3.10

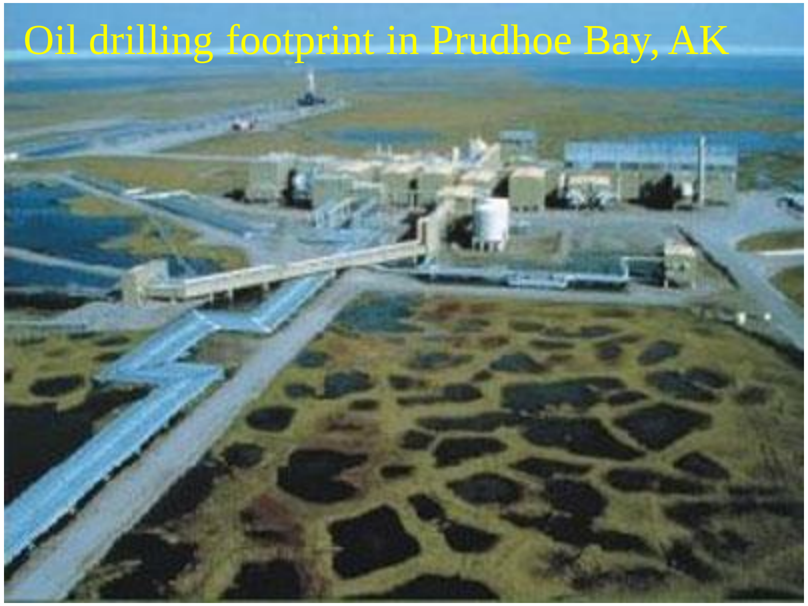
http://www.ngsprints.co.uk/images/M/705167.jpg

Human settlements are sparse in the tundra,

- Contains some of most pristine habitats on Earth
- Animals include caribou and musk oxen, and many migratory birds nest there
- Also predators such as wolves and brown bears, which have been extirpated throughout much of their previous range in other biomes



http://www.alaska-in-pictures.com/data/media/10/denali-bull-caribou_8198.jpg http://static.howstuffworks.com/gif/federal-land-oil-drilling-3.jpg



Human influence on tundra is increasing, as exploration and development of energy resources increases

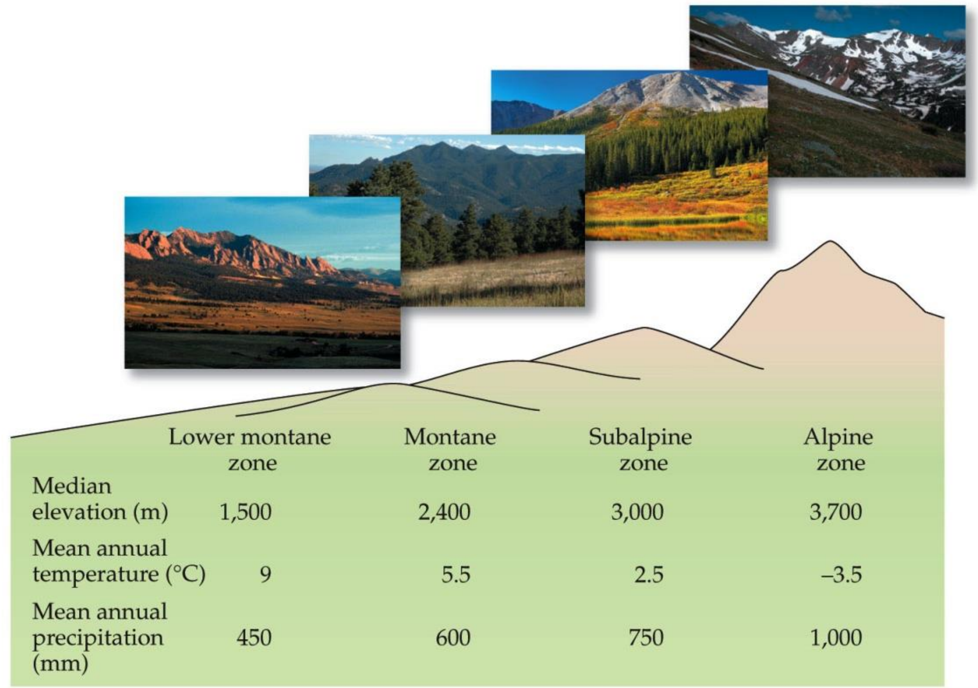
- Arctic has experienced significant climate change during the late 20th and early 21st centuries, with warming almost double the global average

http://lh6.ggpht.com/etosamoe/SFwsl1sS2bI/AAAAAAAAAQo/uHP8RWPN3Ac/55-Permanent_wilderness_thumb%5B1%5D.jpg

Terrestrial Biomes

On mountains temperature and precipitation change with elevation

- Results in bands of biotic assemblages similar to biomes
- Also smaller scale variations associated with slope aspect, proximity to streams, and prevailing winds



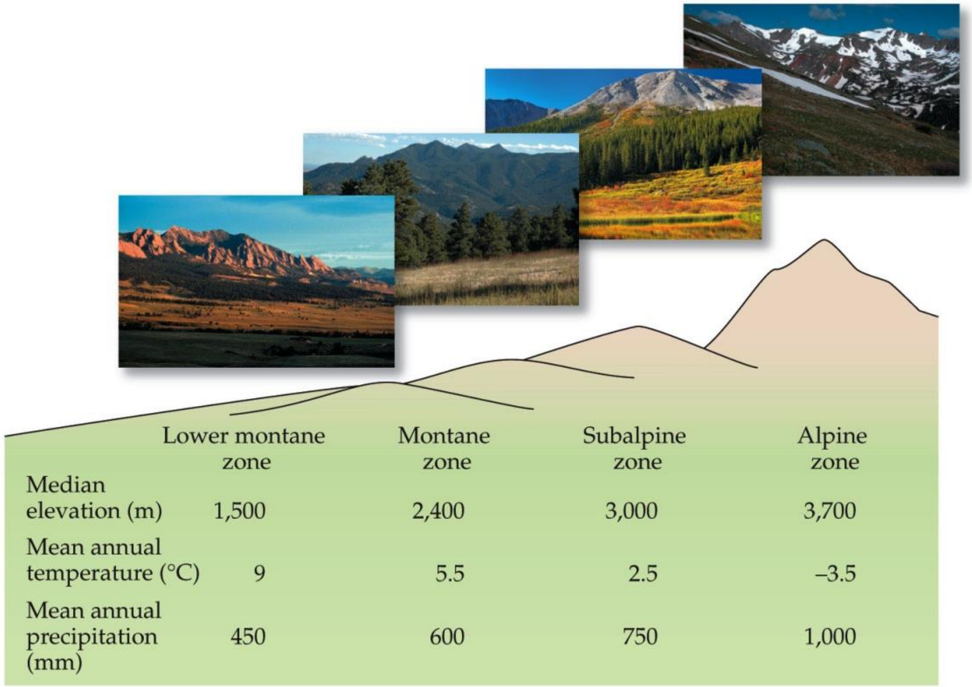
ECOLOGY, **Figure 3.11**

	Lower montane zone	Montane zone	Subalpine zone	Alpine zone
Median elevation (m)	1,500	2,400	3,000	3,700
Mean annual temperature (°C)	9	5.5	2.5	–3.5
Mean annual precipitation (mm)	450	600	750	1,000

ECOLOGY, Figure 3.11

For example, the southern Rocky Mountains

- Vegetation changes from grassland to alpine over 2200 m elevation, comparable to 27° of latitude
- Alpine zone is similar to Arctic tundra, but with higher winds, more intense solar radiation, and lower atmospheric pressure

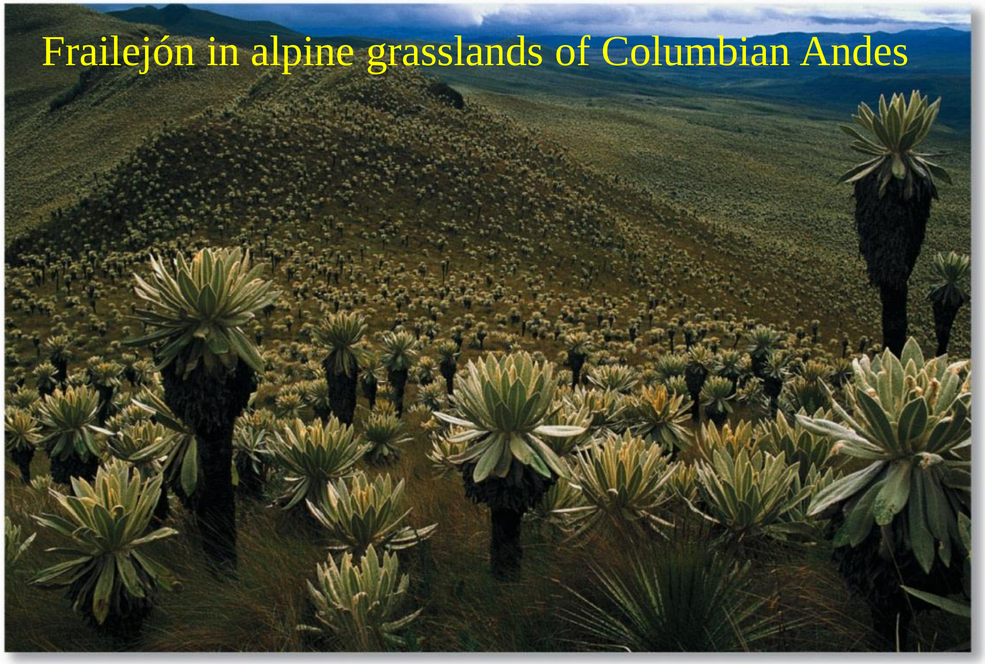


ECOLOGY, Figure 3.11

Some mountain communities have no biome analogs

- For example, tropical alpine vegetation does not resemble tundra — daily temperature variation is greater than seasonal variation

http://artemis.austincollege.edu/acad/bio/sgoldsmith/hawaii02_images2/silverswords.jpg



ECOLOGY, **Figure 3.12**

Figure 3.12 Tropical Alpine Plants

ECOLOGY, Figure 3.12

Freshwater Biological Zones

Concept 3.2: Biological zones in freshwater systems are associated with the velocity, depth, temperature, clarity, and chemistry of the water.

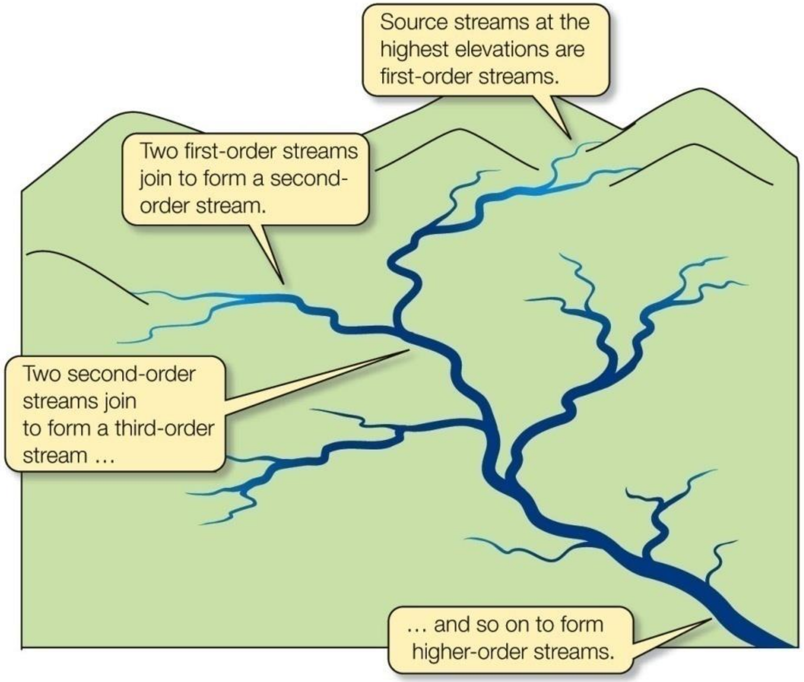
Freshwater streams and lakes are key connection between terrestrial and marine ecosystems

- They process inputs of chemical elements and energy from terrestrial systems and transport them to the oceans
- Land surfaces are partly shaped by erosional power of water flowing downhill

Freshwater Biological Zones

Streams and rivers are **lotic** (flowing water) systems

- Smallest streams at high elevation are first-order streams
- 1^{st} -order streams converge to form 2^{nd} -order streams
- Large rivers are 6^{th} -order streams or greater.

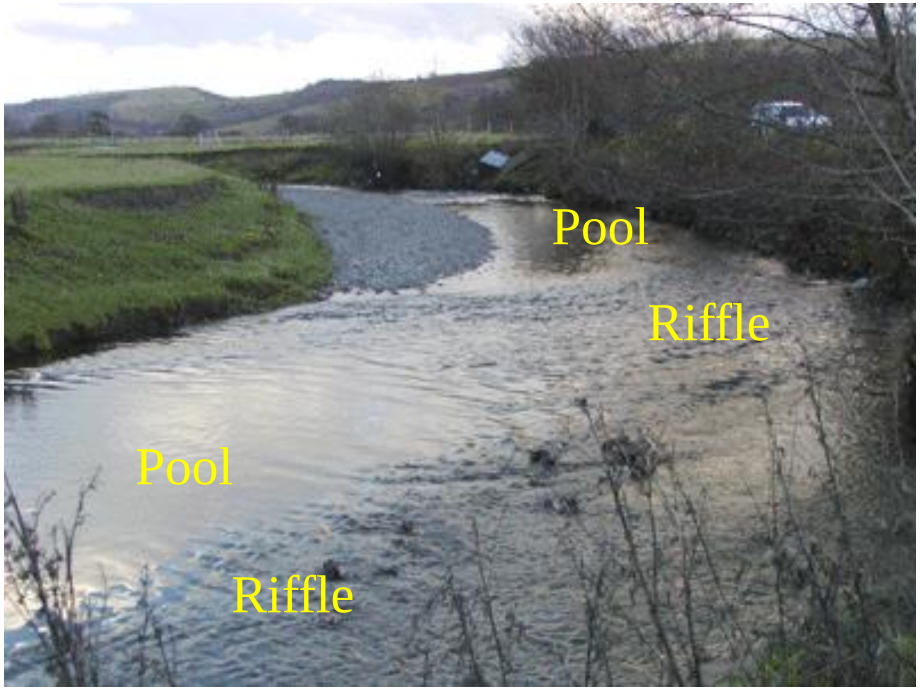


ECOLOGY, **Figure 3.13**

Freshwater Biological Zones

Pattern of riffles and pools tends to form in streams

- **Riffles** – fast moving water with coarse particles on the stream bed
- **Pools –** deeper and slower flow, and calmer surface; finer sediments

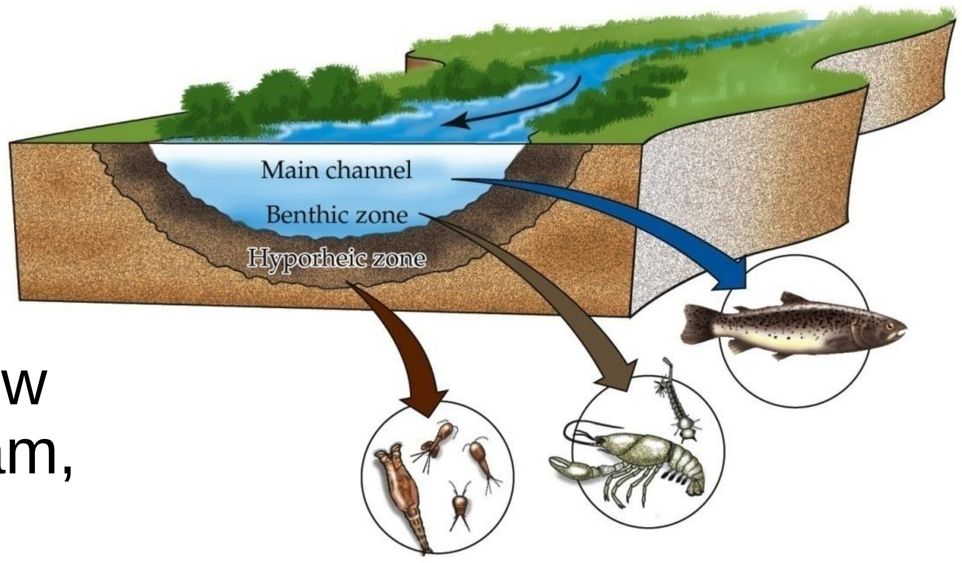


http://www.filter.ac.uk/database/image.php?id=655

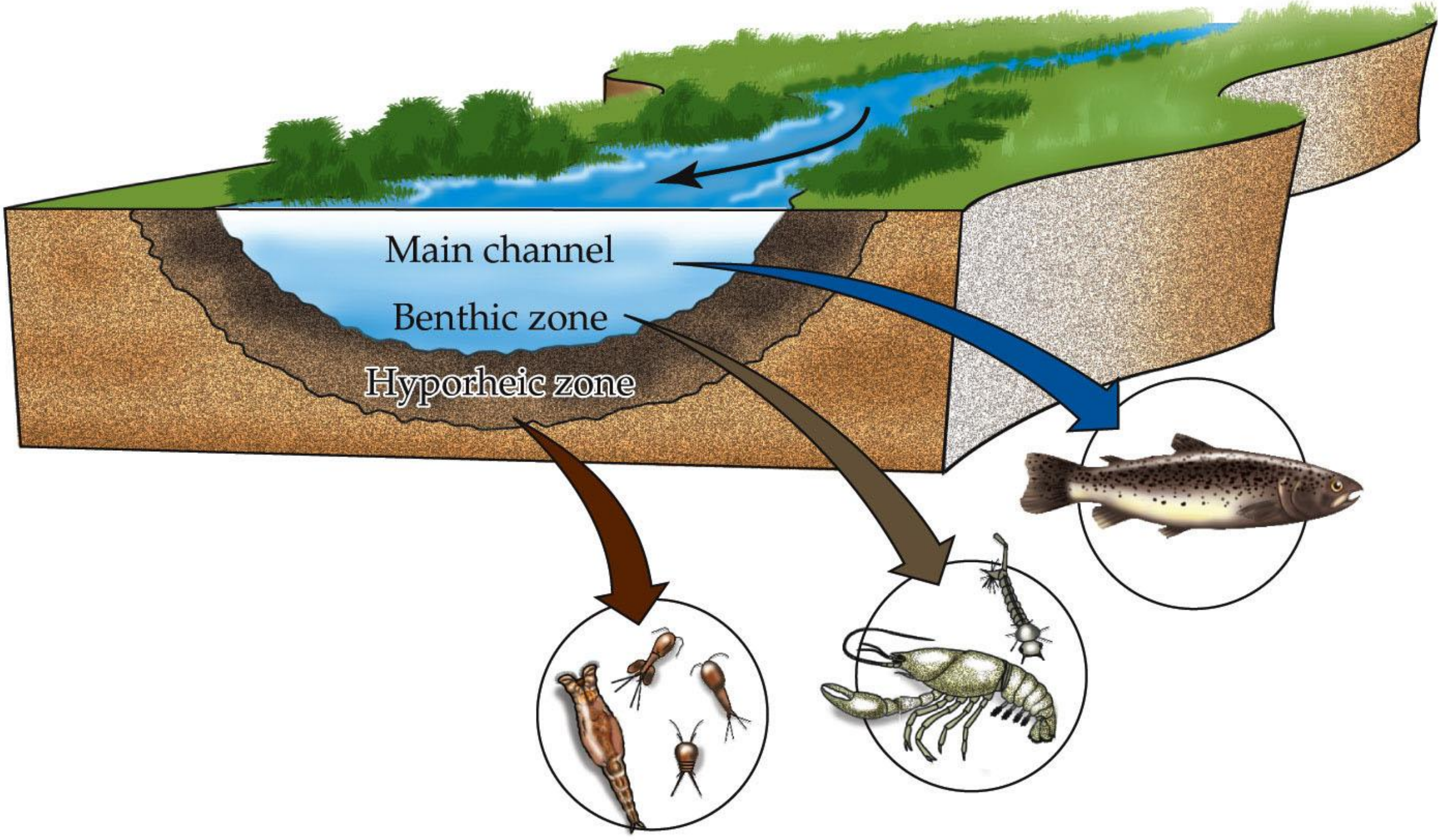
Freshwater Biological Zones

Benthic organisms

- Bottom dwellers, and include many kinds of invertebrates
- Some feed on **detritus** (dead organic matter), others are predators
- Some live in **hyporheic zone** — substratum below and adjacent to the stream, where there is water movement from the stream or from groundwater



ECOLOGY, Figure 3.14

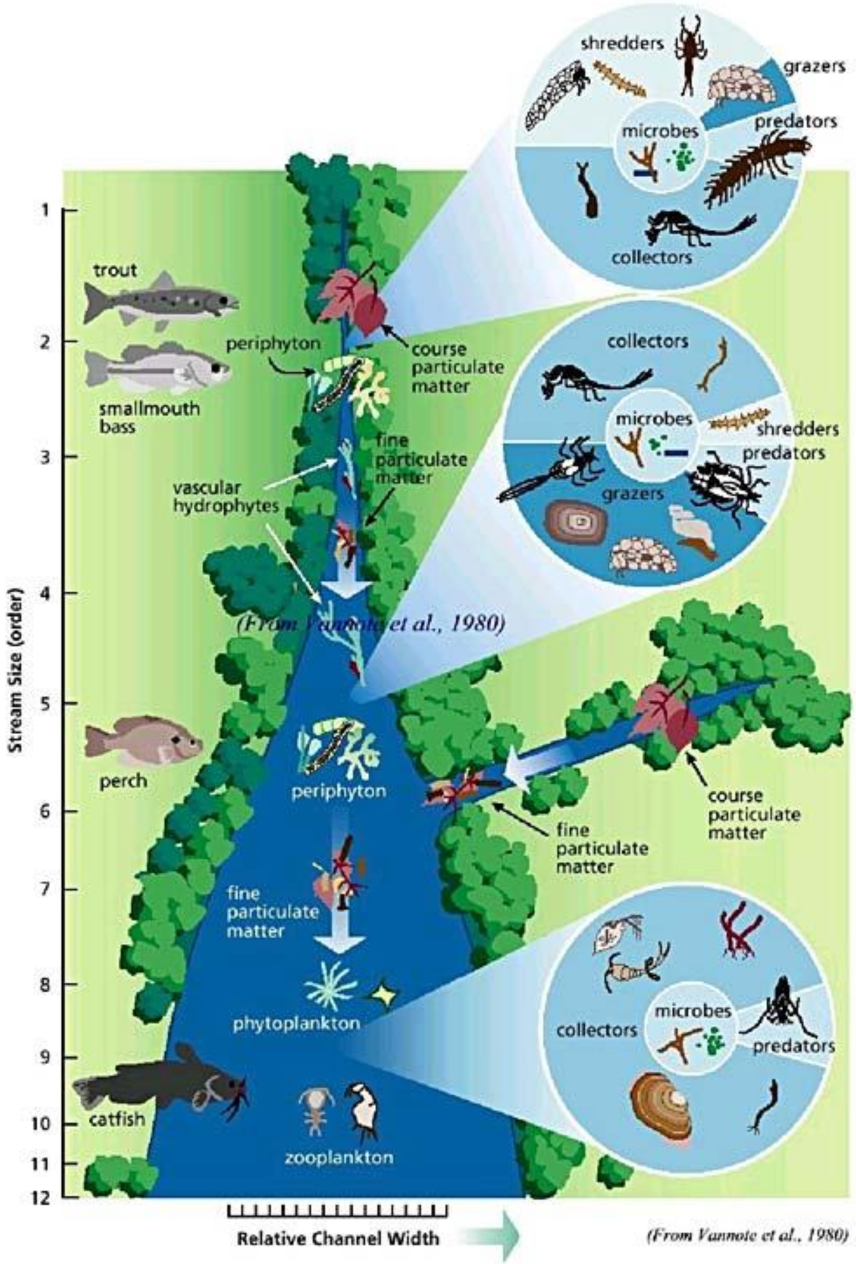


ECOLOGY, Figure 3.14

Freshwater Biological Zones

River continuum concept

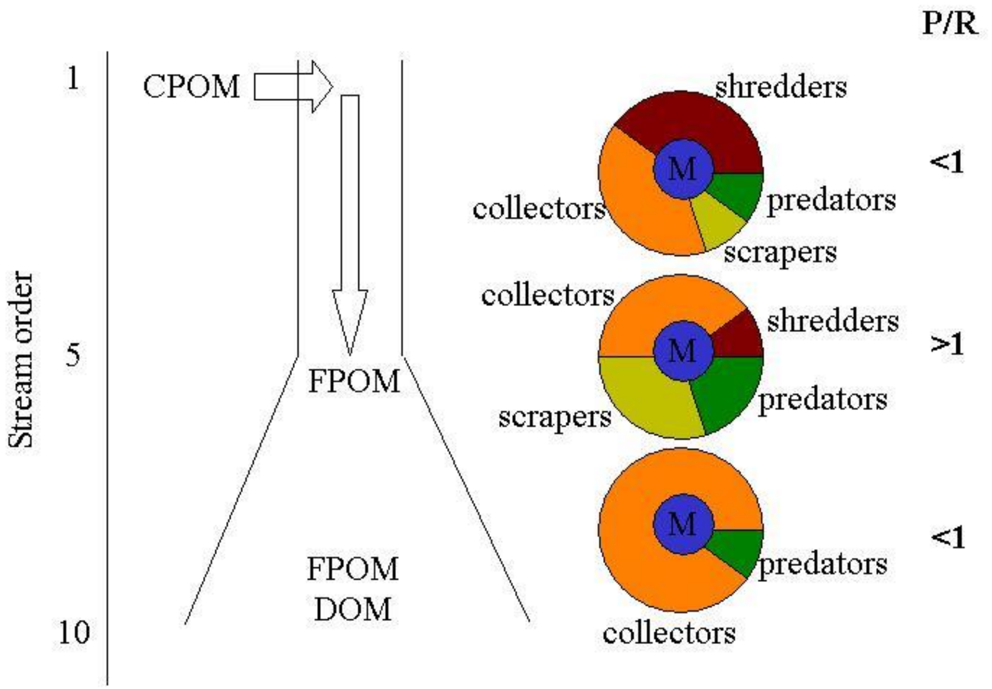
- Describes compositional changes of biological communities with stream order and channel size (Vannote et al. 1980)
- As streams increase in size, detrital input from coarser *riparian vegetation* decreases and importance of detritus as a food source decreases



http://www.oxbowriver.com/Web_Images/Stream_Ecology_Images/RCC/OEPA-RCCpsd.jpg

Freshwater Biological Zones

- Downstream, importance of *fine organic matter*, algae, and **macrophytes** (rooted aquatic plants) as food sources increases
- Feeding styles of organisms also change → from *shredders* (tear up and chew leaves) to *collectors* (collect fine particles from the water)

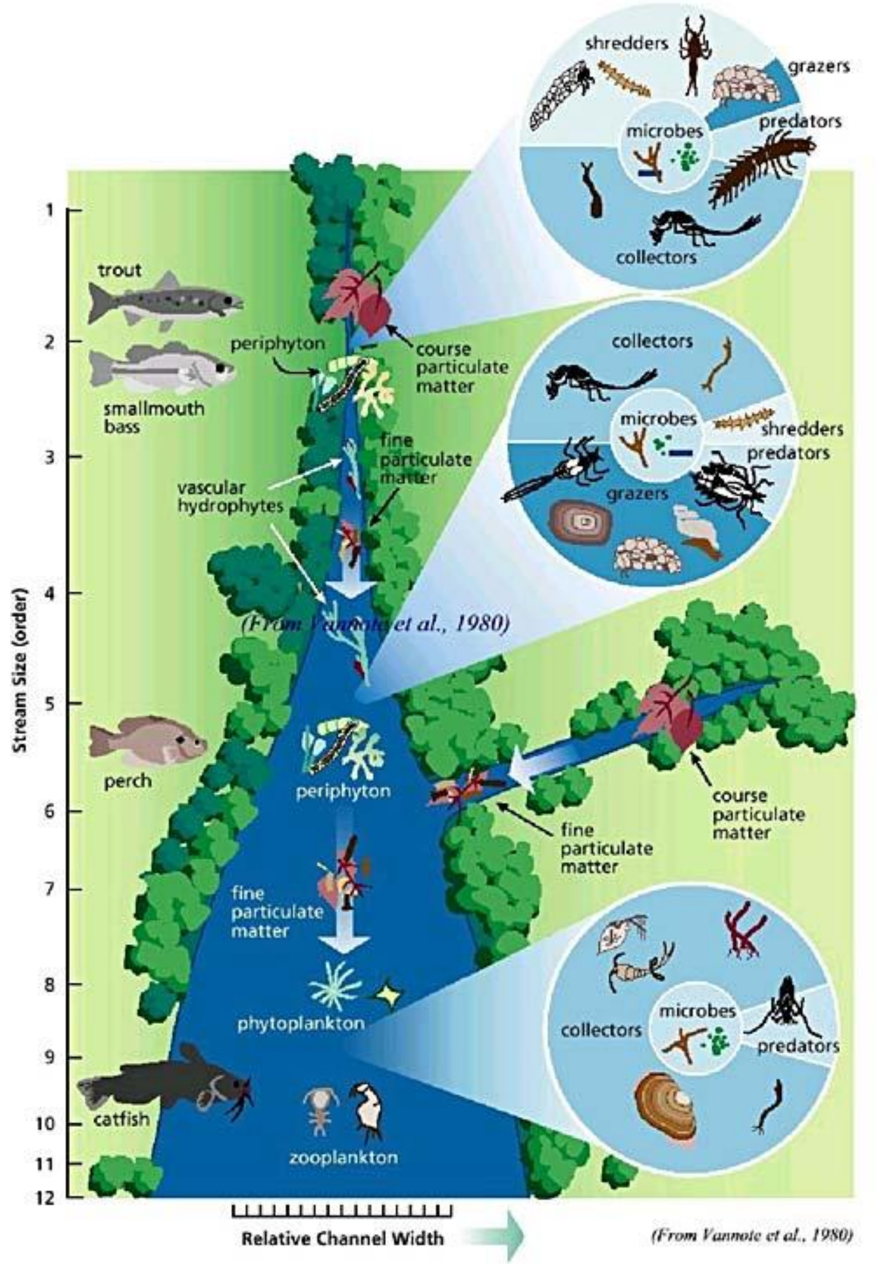


CPOM – coarse particulate organic matter
FPOM – fine particulate organic matter
DOM – dissolved organic matter

Freshwater Biological Zones

- The river continuum concept applies best to temperate river systems, and not so well to Arctic/boreal and tropical rivers, and those with high humic acids in wetlands

- Provides a basic model for the study of stream systems

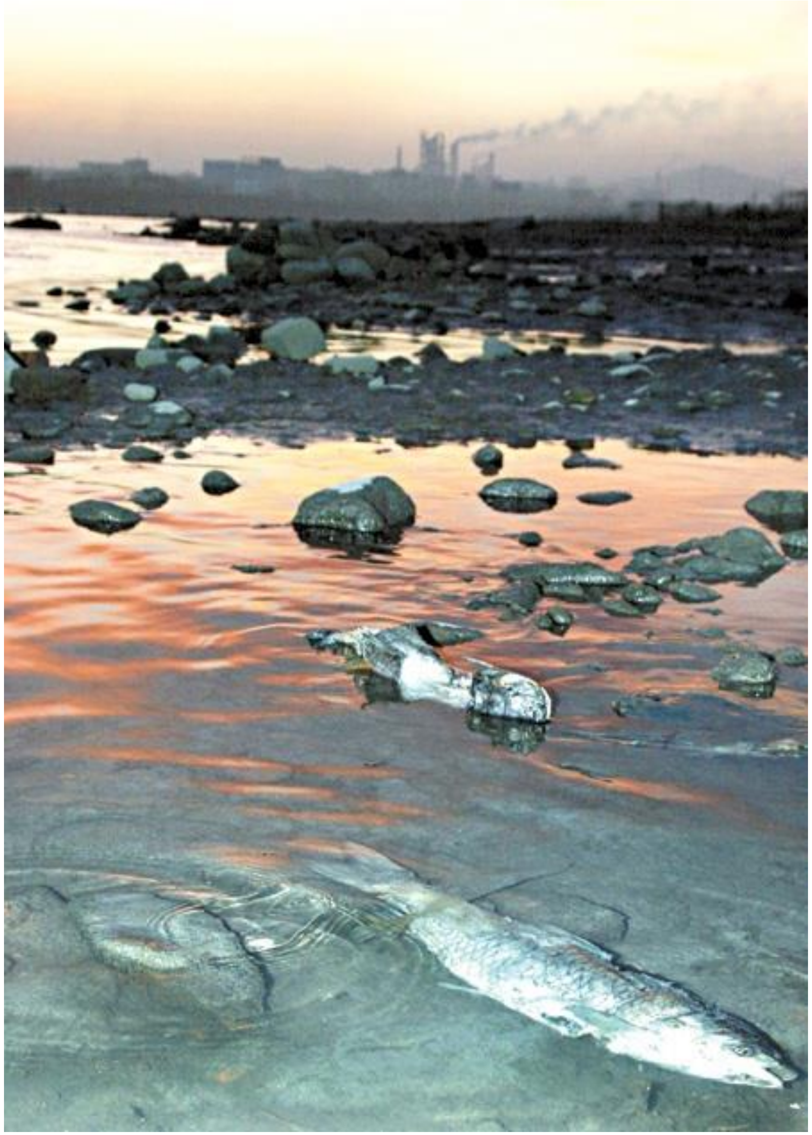


http://www.oxbowriver.com/Web_Images/Stream_Ecology_Images/RCC/OEPA-RCCpsd.jpg

Freshwater Biological Zones

Human effects on streams include pollution, sediment inputs, and introduced species

- Streams have always been used for disposal of sewage and industrial wastes
- Can often reach levels toxic to organisms



Dead fish washed up along the banks of the Songhua River after the recent explosion at a chemical plant in Jilin city, Northeast China's Jilin Province, Wednesday. The chemical leak polluted the river, and forced Harbin to stop its water supply for four days starting Tuesday midnight. (China Daily/AFP photo)

http://english.peopledaily.com.cn/200511/24/archive.html

Freshwater Biological Zones

Excessive fertilizer use in croplands results in runoff and leaching of nutrients to streams and groundwater

- Deforestation increases sediment inputs into streams, which can reduce water clarity, alter benthic habitat, and inhibit gill function in many aquatic organisms

http://www.eateco.org/images/ManureStream.jpg

Freshwater Biological Zones

www.tnfish.org/InvasivesExoticSpeciesTennessee_TWRA

Non-native species, including sport fishes, have lowered biodiversity in streams and lakes

Brown trout have been introduced into many streams in North America to enhance sport fishing, but have reduced many native trout species.

http://www.alladale.com/images/body_content/wildlife/brown_trout.jpg

This species of "Asian carp" is known for its explosive leaping abilities and poses a serious threat to boaters and aquatic communities. They have the potential to disrupt native food chains.

Freshwater Biological Zones

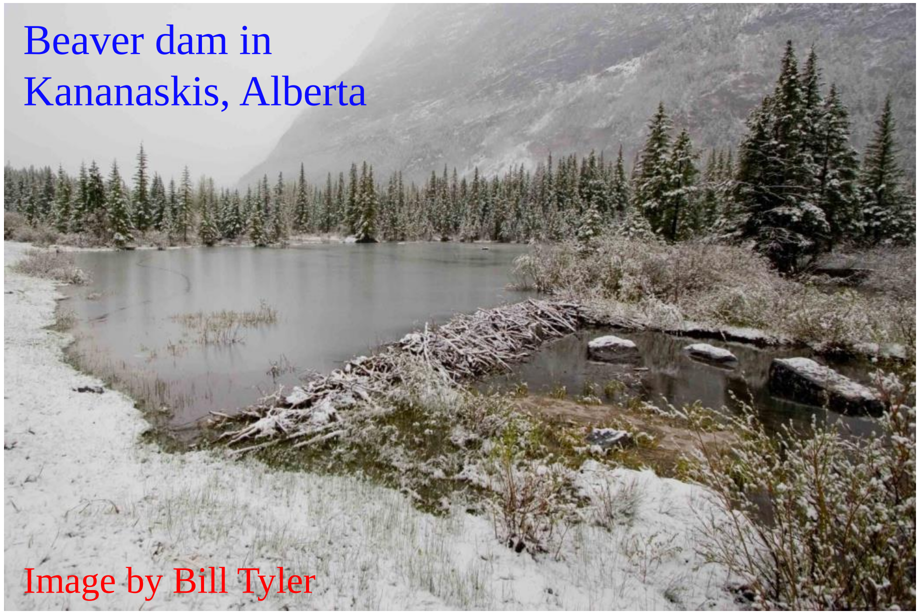
Construction of dams tremendously alters the physical and biological properties of streams, converting them to “stillwater” systems

http://www.virtualmuseum.ca/Exhibitions/Hydro/_img/dams/reg/BCH_Elko_Dam.jpg

Freshwater Biological Zones

Lakes and still waters (**lentic**) occur where depressions in the landscape fill with water

- Lakes can be formed by glacial processes, from river oxbows, in volcanic craters, in tectonic basins, or by animal activities, including humans and beavers



http://www.uwsp.edu/geo/faculty/ritter/images/lithosphere/fluvial/oxbow_lake_large.jpg

Freshwater Biological Zones

Lakes vary greatly in size.

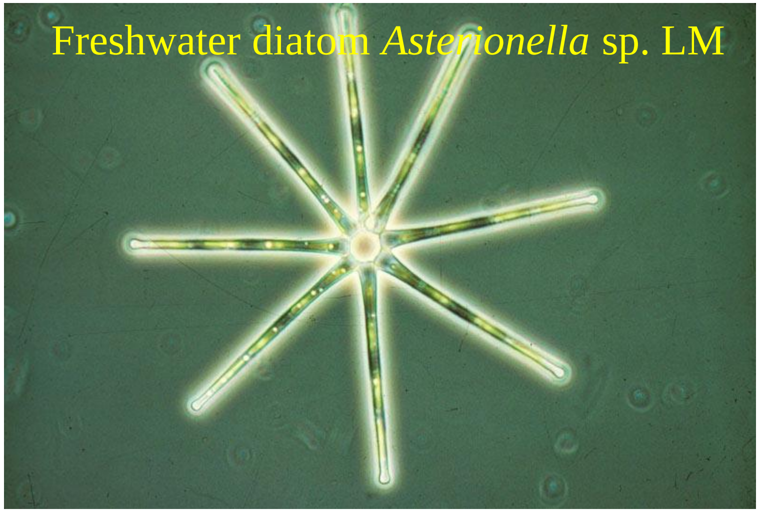
- Depth and area of lake has important consequences for composition of its biological communities
- Deep lakes with a relatively small surface area tend to be nutrient-poor compared with shallow lakes with a relatively large surface area

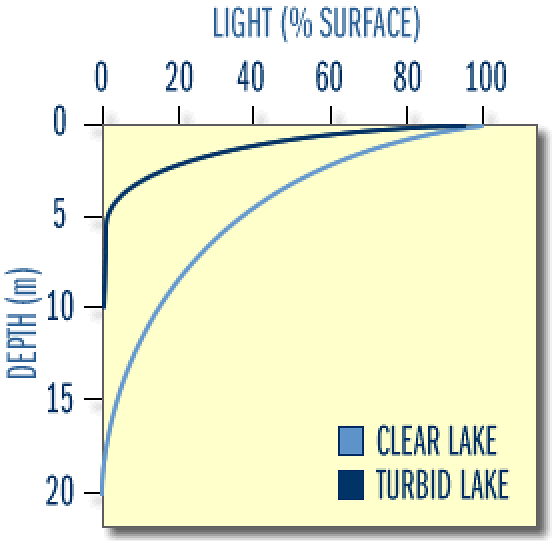
http://media-2.web.britannica.com/eb-media/08/12608-004-C194ED9C.jpg

Freshwater Biological Zones

Biological assemblages determined by depth and degree of light penetration

- **Pelagic zone**
  - Open water
  - Dominated by **plankton** (small and microscopic organisms suspended in the water)
  - Photosynthetic plankton (**phytoplankton**) are limited to upper layers through which light penetrates (**photic zone**)



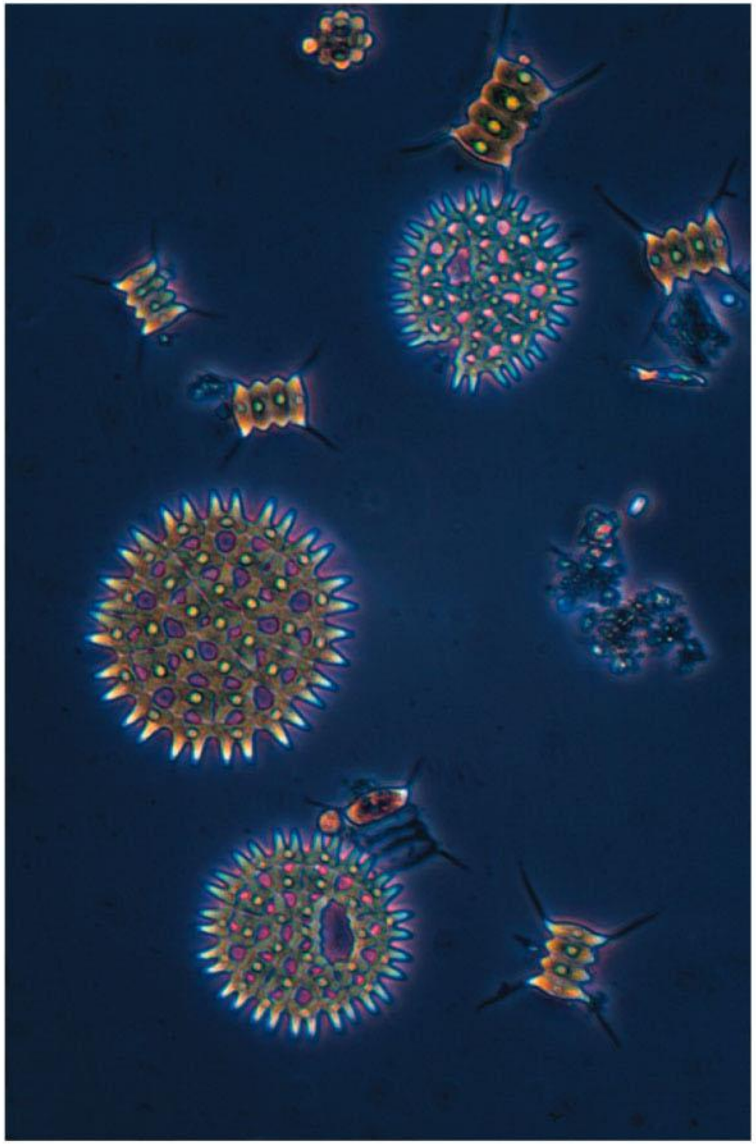


LIGHT VERSUS DEPTH PROFILES FOR A CLEAR LAKE ($k=0.2\ M^{-1}$) AND A TURBID LAKE ($k=0.9\ M^{-1}$).

http://science.kennesaw.edu/~jdirnber/limno/LecPhy/lightDepth.GIF

Figure 3.15 Examples of Lake Plankton

(A) Phytoplankton



(B) Zooplankton

Freshwater Biological Zones

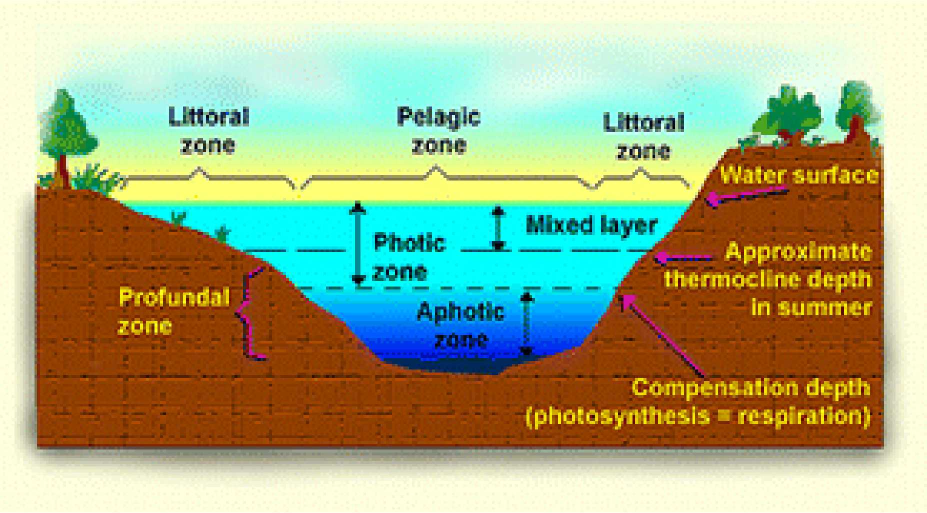
http://www.glasstraps.com/images/plants/anubias1.jpg

Littoral zone is near shore

- Where photic zone reaches bottom
- Macrophytes occur in this zone

Benthic zone

- Detritus derived from littoral and pelagic zones serves as energy source for animals, fungi, and bacteria
- May be cold and have low oxygen



http://www.aquatic.uoguelph.ca/lakes/images/zone.gif

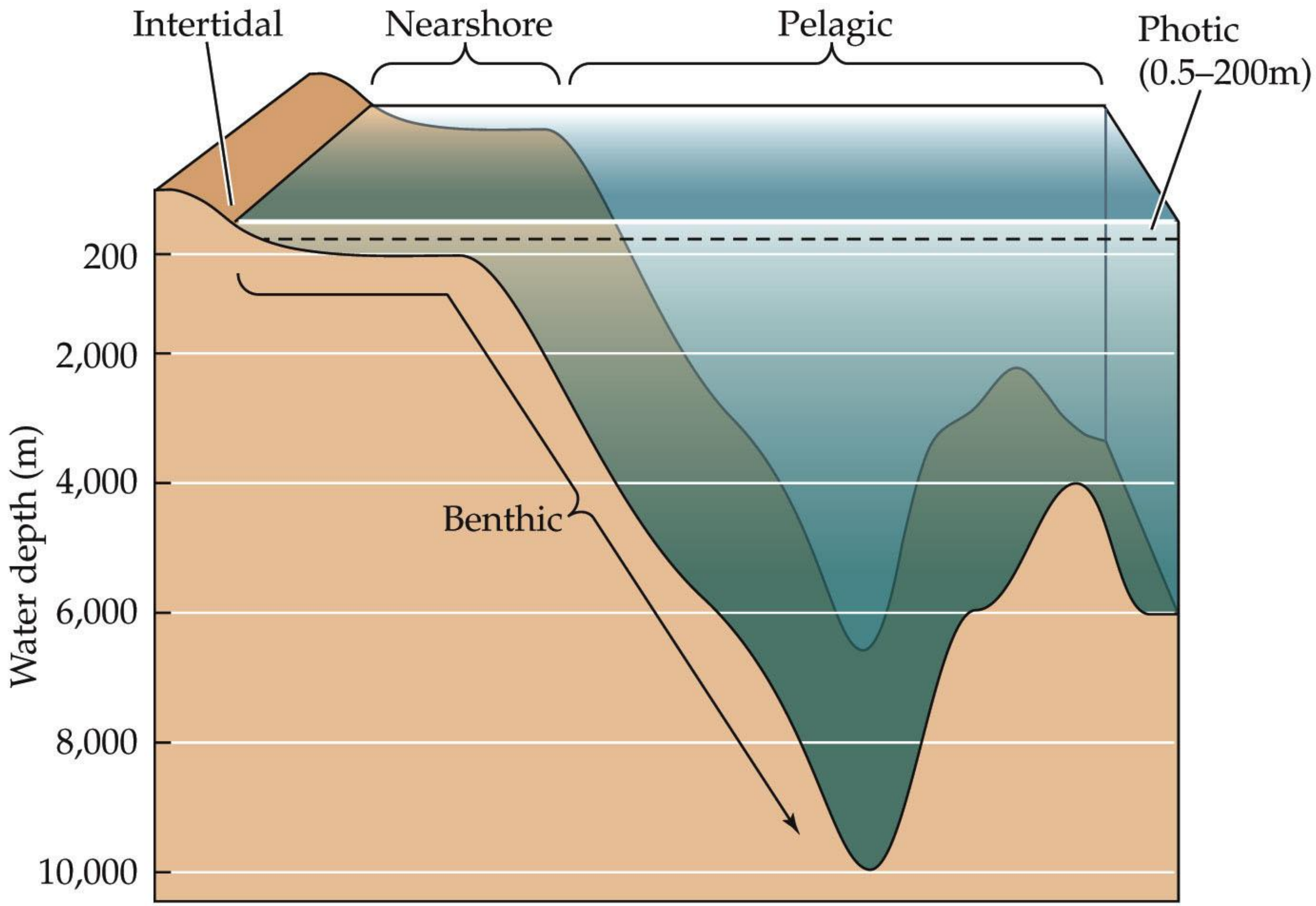
Concept 3.3: Marine biological zones are determined by ocean depth, light availability, and the stability of the bottom substratum.

- Oceans cover 71% of Earth's surface and contain a rich diversity of unique biota

Review section on your own

http://www.payvand.com/news/08/jun/Earth-BlueMarble-NAASA.jpg

- Marine zone are categorized by depth and relationship to shorelines



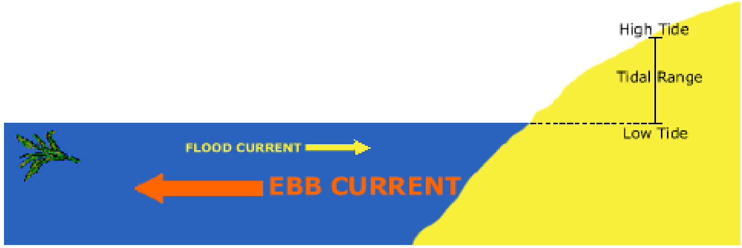
ECOLOGY, Figure 3.16

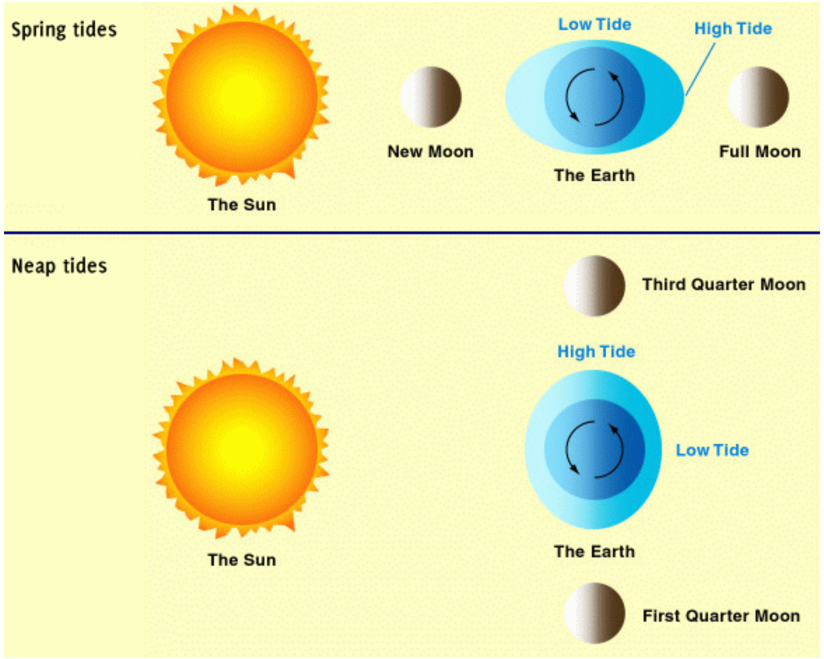
Marine Biological Zones

http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/images/animations/lithosphere/tide01_480_NOAA.gif

Marine zones next to continents are influenced by tides and wave action

- Tides are generated by gravitational attraction between Earth and moon and sun
- The magnitude of tidal ranges varies by location and is related to shoreline morphology and ocean bottom structure





http://www.sciencehelpdesk.com/img/science1_4/Tides2.gif

Estuaries occur at junctions of rivers and oceans

- Salinity varies as fresh water flows in from the river and salt water flows in from the sea.
- Rivers also bring terrestrial sediments and nutrients, contributing to the productivity of estuaries.

http://www.sms.si.edu/irlspec/images/07PhotoContest/07OwenP2.jpg

Figure 3.17 Estuaries Are Found at the Junction of Rivers and Oceans

Salinity variation influences organisms that live in estuaries

- Many fish and sea turtles spend juvenile stages there, away from predators that cannot tolerate salinity change

http://www.int-res.com/uploads/pics/featureMEPS318_large.jpg

http://www.mcsuk.org/images/trackturtle/turtle_grass.jpg

Marine Biological Zones

- Many shellfish and other invertebrates also live in estuaries
  - Oysters get refuge in estuaries; oyster drills cannot tolerate low salinities

Crassostrea virginica – American oysters

Urosalpinx cinerea - Atlantic Oyster Drill laying eggs

http://score.dnr.sc.gov/ktmlpro10/images/uploads/oysterbed.jpg

http://farm4.static.flickr.com/3265/2607133657_b75260625d.jpg?v=0

Estuaries are increasingly threatened by pollution carried in rivers

- Nutrients from agriculture can create local dead zones (anoxia), and loss of biodiversity
- Urban runoff and releases of nutrient-rich waters from Lake Okeechobee affect Florida estuarine systems

Residential areas along the banks of the C-23 and C-24 canals in Port St. Lucie, leading into the Indian River Lagoon.

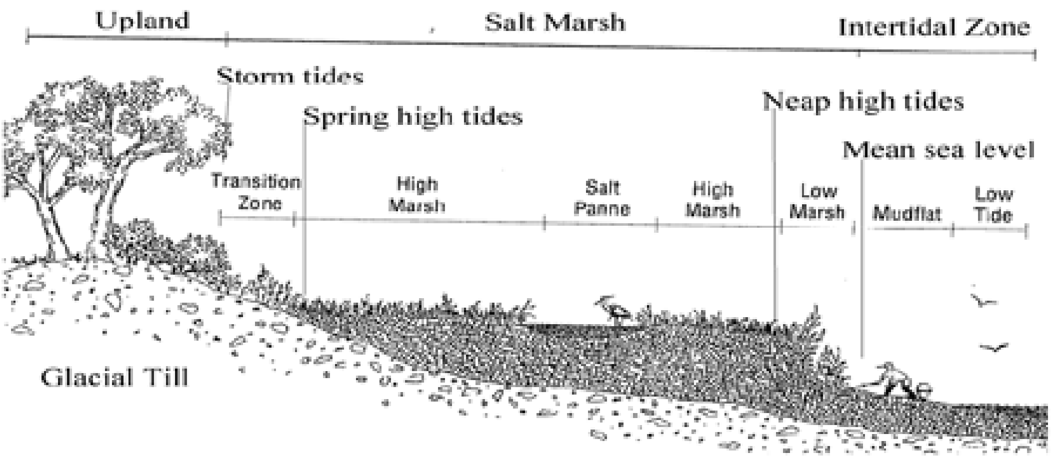
http://www.sjrwmd.com/irlupdate/images/PortStLucie_canal.jpg

Algal bloom in the Caloosahatchee River

http://crca.caloosahatchee.org/img/P1080556_2.jpg http://www.eserc.stonybrook.edu:8080/FlaxPondDigitalLibrary/2004/images/FPDL20040024.jpg

Salt marshes

- Shallow coastal wetlands dominated by emergent plants such as grasses and rushes
- Terrestrial nutrients enhance productivity
- Plants occur in zones that reflect salinity gradients resulting from periodic flooding at high tide – the highest zone is most saline (gets least flooding)



http://www.npa-pan.ca/en/publications/factsheets/images/saltmarsh_1.gif

Figure 3.18 Salt Marshes are Characterized by Salt-Tolerant Vascular Plants

Marine Biological Zones

In tropics and subtropics, coastal zones can be dominated by **mangrove forests**

- Salt-tolerant, evergreen trees and shrubs
- Mangroves include species from 16 different plant families
- Mangrove roots trap sediments carried by water, which build up and modify shoreline

http://www.ramsar.org/pictures/panamerican2004-07.jpg

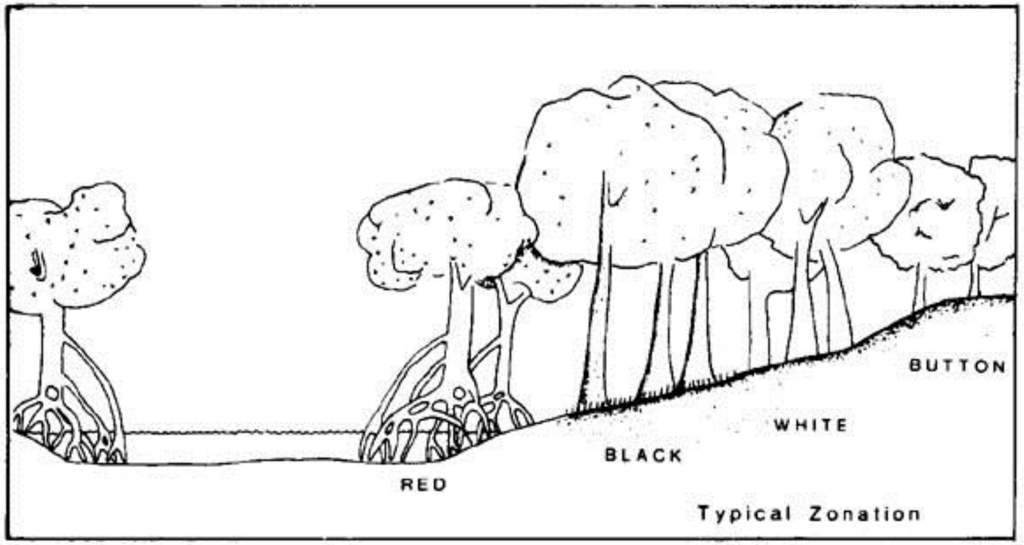
Figure 3.19 Salt-Tolerant Evergreen Trees and Shrubs Form Mangrove Forests

Marine Biological Zones

Mangrove forests also exhibit zonation based on salinity tolerances, from water toward land…

- **Red mangroves** prevent salt uptake at the roots – *salt excluders*
- **Black mangroves** have pnuematophores to “breathe” in anoxic soil/mud, and have leaf glands that *exude salt*
- **White mangroves** are most salt tolerant, *secreting salt* from leaf glands

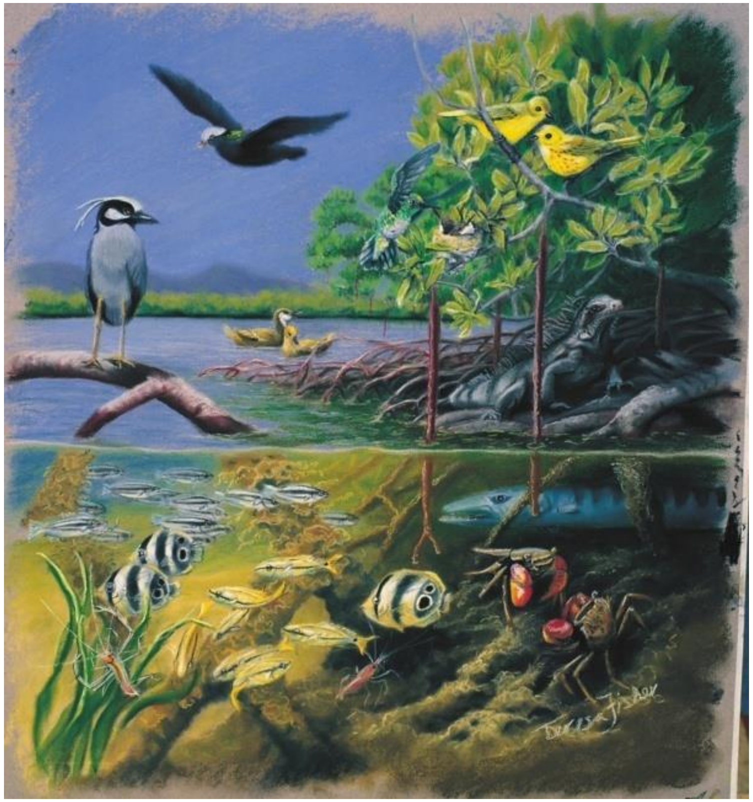
You should know this zonation living in Florida



http://cavehill.uwi.edu/FPAS/bcs/courses/Ecology/ECOL2453/ecol2453_sc/mangrove1.jpg

Mangrove forests provide nutrients to other marine ecosystems and habitat for many animals

- Unique animals associated with mangroves include manatees, crab-eating monkeys, fishing cats, and monitor lizards
- Serve as nurseries for commercial species
- Protect shorelines from erosion and hurricane damage



http://bcrc.bio.umass.edu/vifishandwildlife/Education/AquaticEd/Posters/MangroveHabitats.jpg

Marine Biological Zones

- Mangroves are threatened by human development, particularly shrimp farms, water pollution, diversion of inland freshwater sources, and cutting

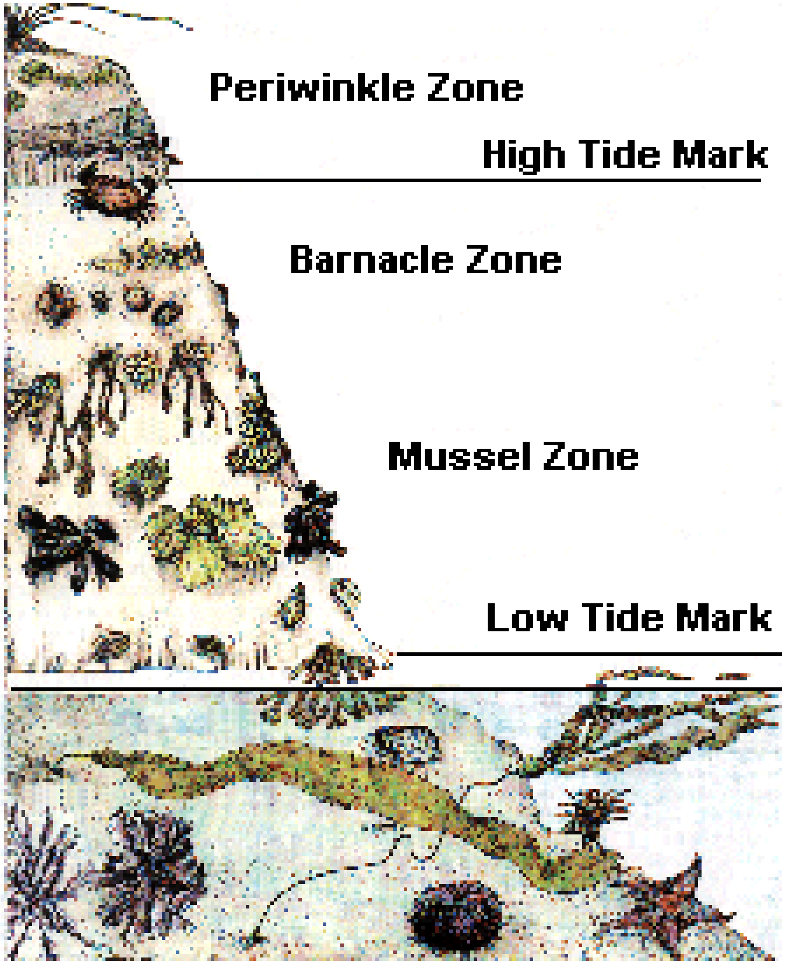
Mangrove habitat lost to shrimp farms in Honduras and Nicaragua

Development in Myanmar mangrove forest

http://cms.mumbaimirror.com/portalfiles/12/8/200805/Image/190508/img07.jpg

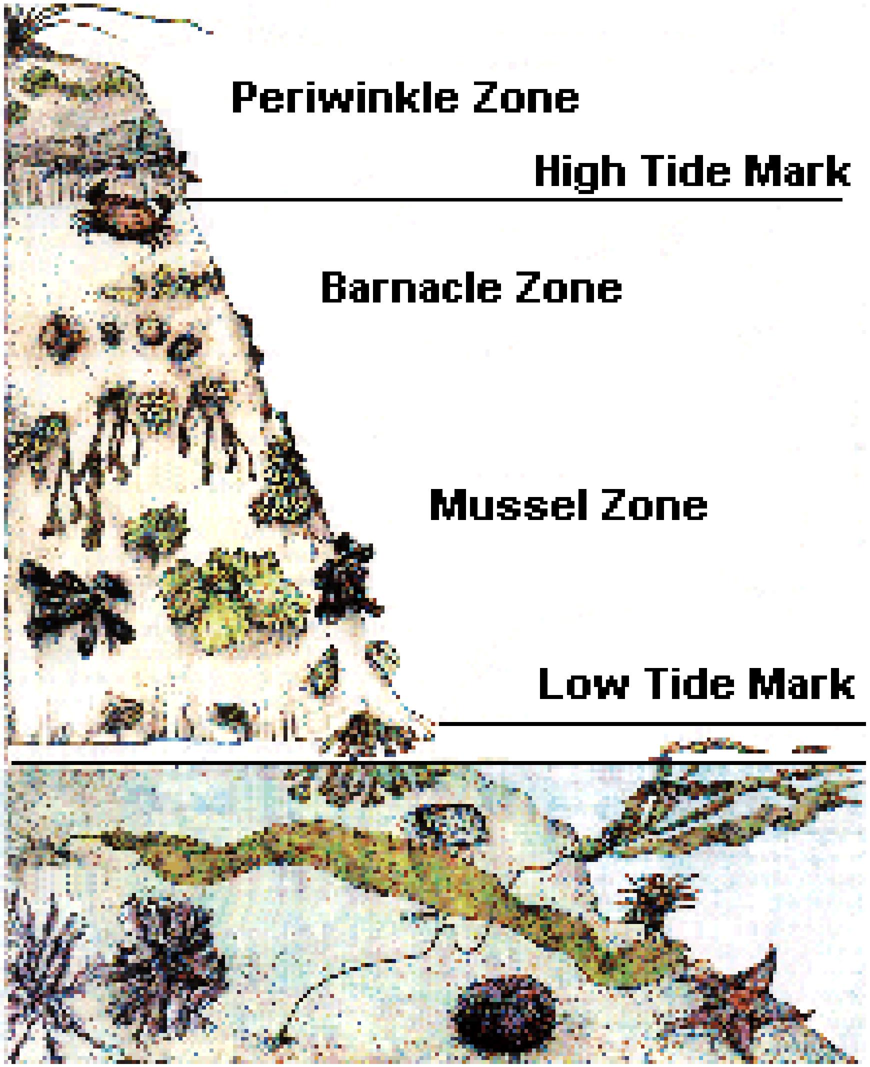
Rocky intertidal zones

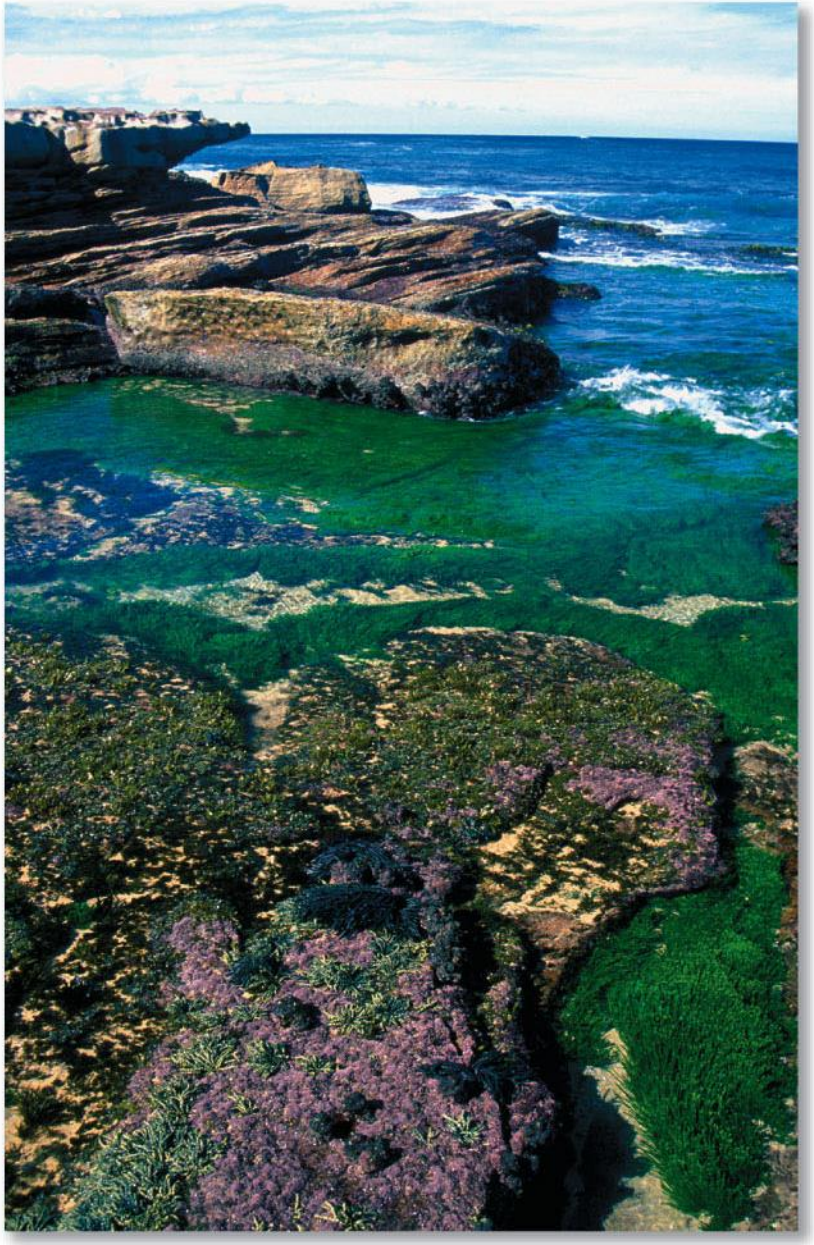
- Provide stable substratum for a diverse collection of algae and animals
- Alternates between marine and terrestrial with rise and fall of tides
- Bands of organisms result, depending on their tolerance to drying, salinity, temperature, and species interactions



http://www.daukas.com/Geoscience/MAtour/CCC/images/tidal.gif

Figure 3.20 The Rocky Intertidal Zone: Stable Substratum, Changing Conditions





http://www.daukas.com/Geoscience/MAtour/CCC/images/tidal.gif

ECOLOGY, Figure 3.20

http://www.racerocks.com/racerock/research/eealex/ecology_halosaccion_files/image004.jpg

Marine Biological Zones

Sessile organisms are fixed in place

- must have mechanisms to tolerate daily changes — barnacles, mussels, seaweeds

Mobile animals can move to pools to avoid *desiccation*

- Sea stars and urchins

http://www.wallawalla.edu/academics/departments/biology/rosario/inverts/Echinodermata/Class%20Asteroidea/Pisaster_ochraceousEatMussel1sDLC2006.jpg http://www.sogonow.com/static/FCKeditor/UserFiles/Image/1,%20beach.JPG

Marine Biological Zones

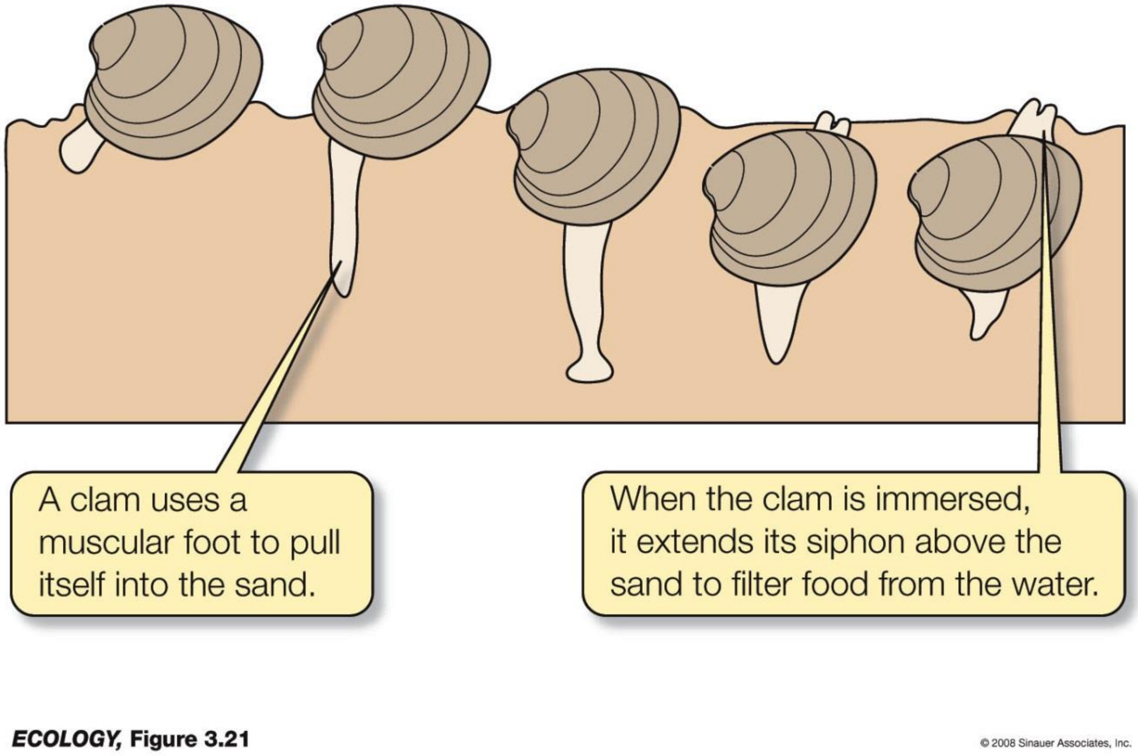
Sandy shores

- Not very stable, have little available food, and lots of wave action
- Many invertebrates burrow into the sand, such as clams, sea worms, and mole crabs

Atlantic Ghost Crab, *Ocypode quadrata*, emerging from burrow

http://www.mongabay.com/images/gabon/600/gabon-30750.JPG

Figure 3.21 Burrowing Clams



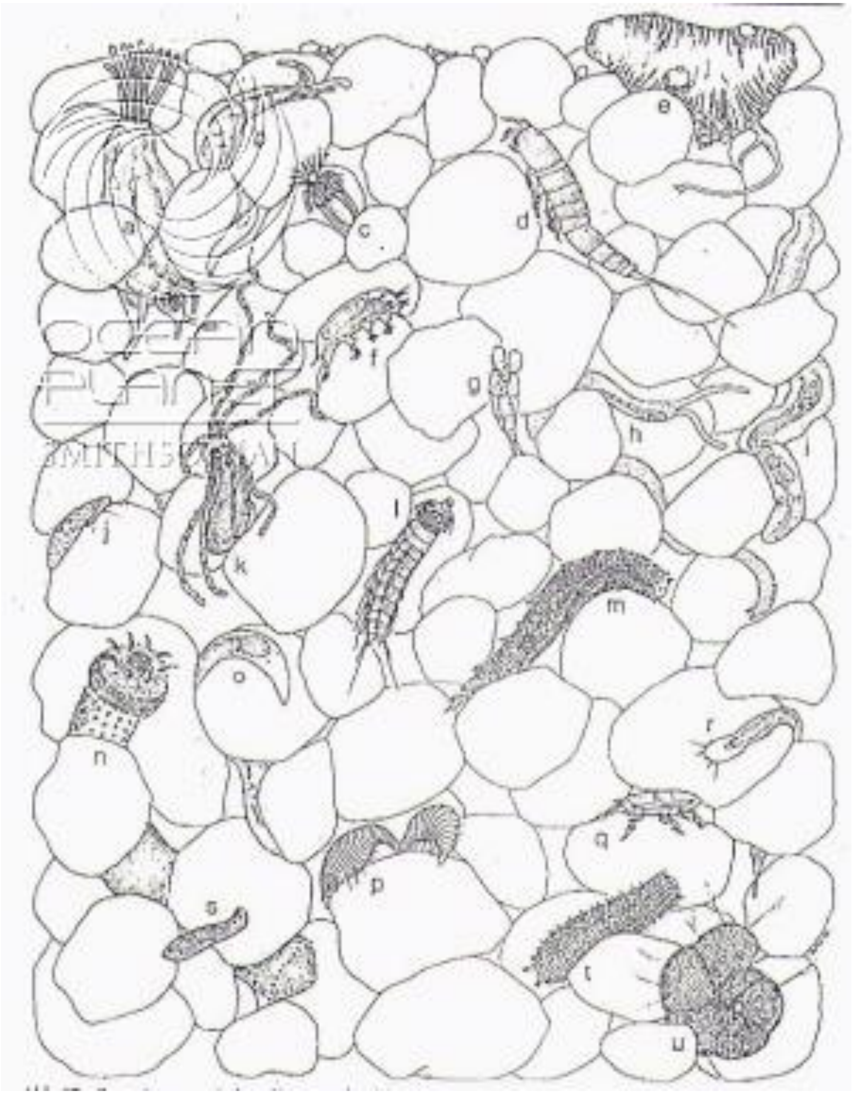
http://www.jaxshells.org/0710aa.jpg

Emerita talpoidea **– Mole crab, a.k.a. sand flea**

Marine Biological Zones

- Smaller organisms, such as polychaete worms, hydroids, tardigrades and copepods live on or among the grains of sand (**meiofauna**)

http://tbn0.google.com/images?q=tbn:I7OeHY2JATUJ::http://bp0.blogger.com/_9s8iqcCd0DY/Rvum-6KorpI/AAAAAAAAA_g/54xtaA72z0Q/s400/tardigrade01.jpg

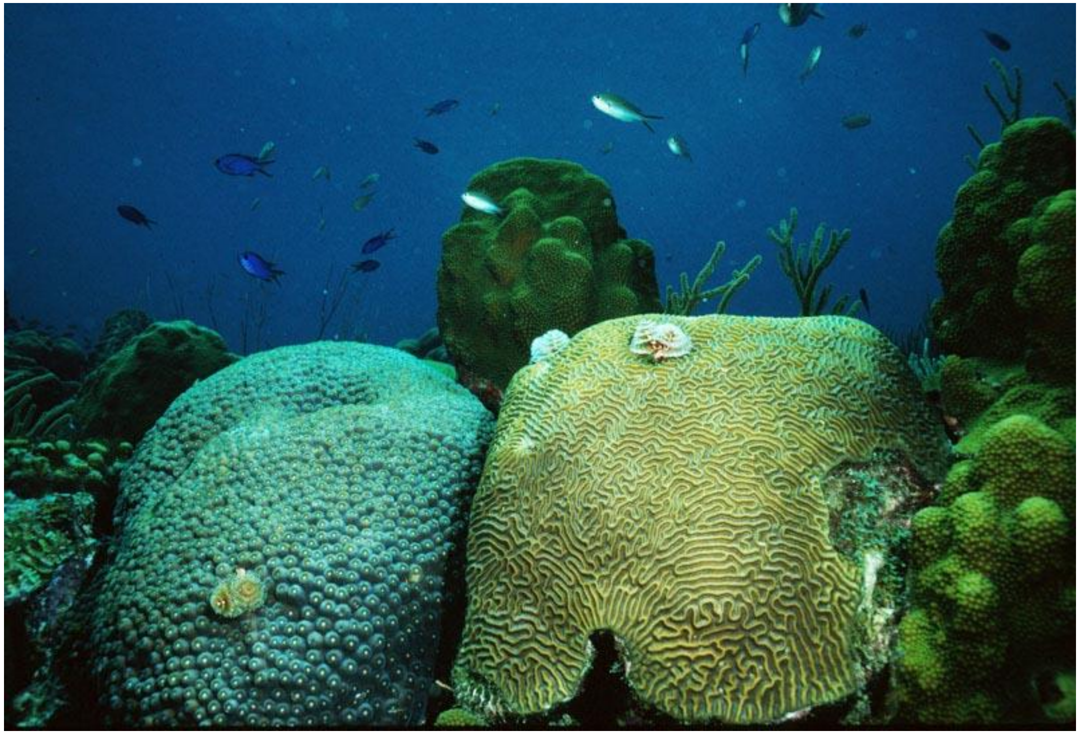


http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/IMAGES/G-534.gif

Marine Biological Zones

Shallow ocean zones allow light to penetrate to the bottom and support photosynthetic organisms

- These organisms support diverse community of other organisms by providing both energy and physical support



Coral reefs

- Restricted to warm, shallow, clear, nutrient-poor water
- Corals are related to jellyfish, form large colonies, and have associated algal partners (**zooxanthellae**)
- Many corals extract calcium carbonate from seawater to build a skeleton-like structure that over time, forms large reefs

Zooxanthellae are symbiotic dinoflagellates that live in tissues of coral and other organisms

http://www.igfa.org/images/zooxanthellae.jpg

***ECOLOGY*, Figure 3.22**

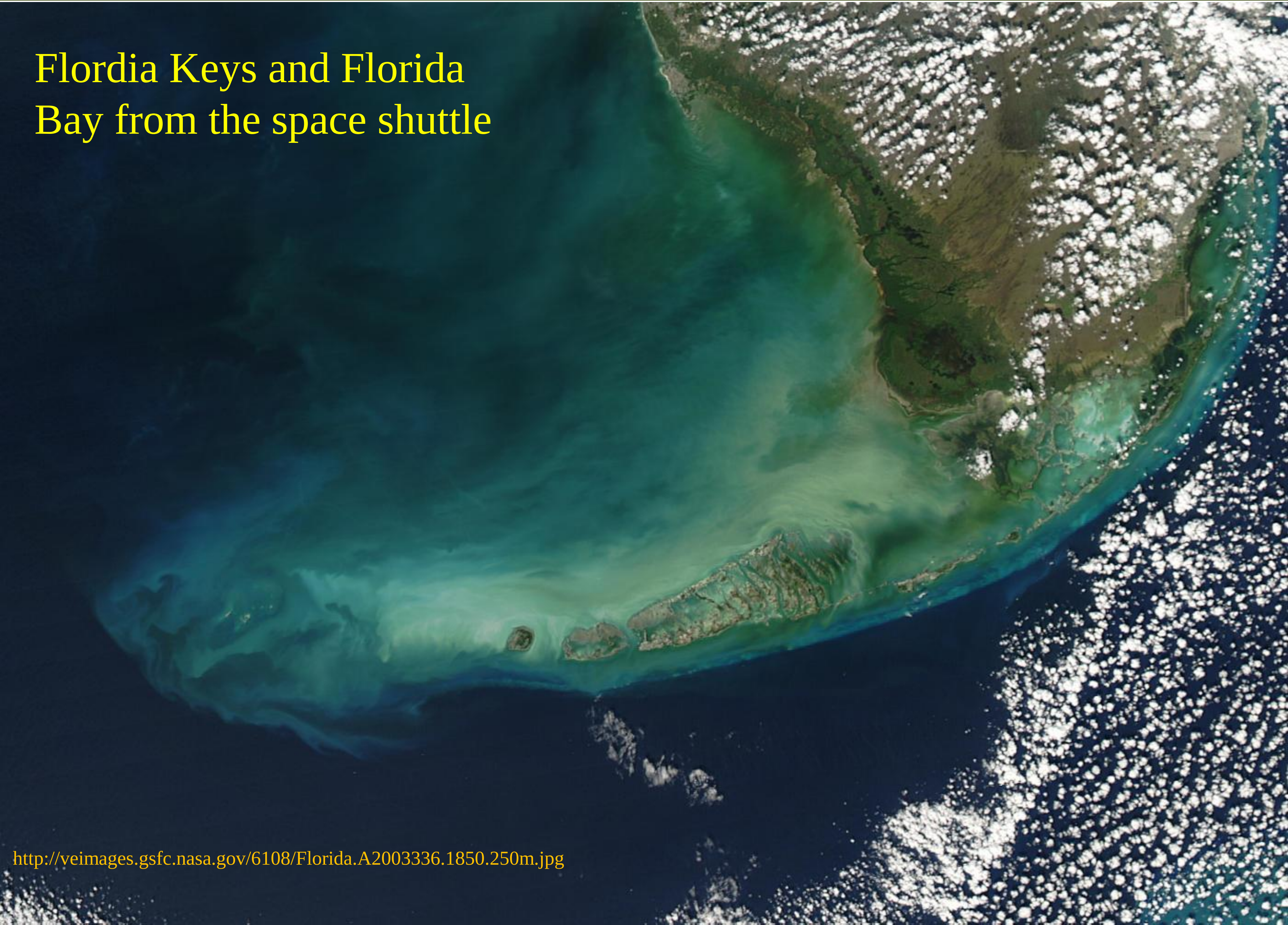
Coral reefs develop complex structural habitat that supports huge diversity of marine life

- Although coral reefs grow slowly, over millions of years, corals have constructed thousands of kilometers of coastline and many islands
- Rates of production of biomass are some of the highest in the world

Great Barrier Reef from space

http://www.solcomhouse.com/images/GreatBarrierReef-EO.jpg

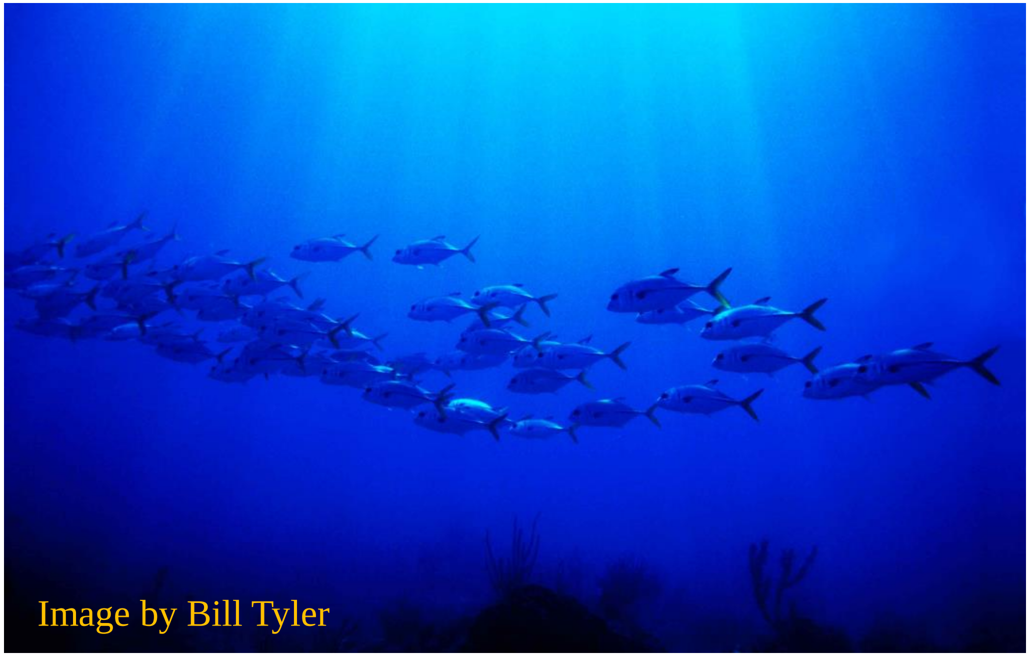
Figure 3.23 Coral Reefs Can Be Seen from Outer Space



Marine Biological Zones

Coral reefs support up to a million species of organisms, the highest diversity on Earth

- Many economically important fishes rely on coral reefs for habitat
- Reef fishes provide food source for fishes of the open ocean, such as jacks and tuna



Marine Biological Zones

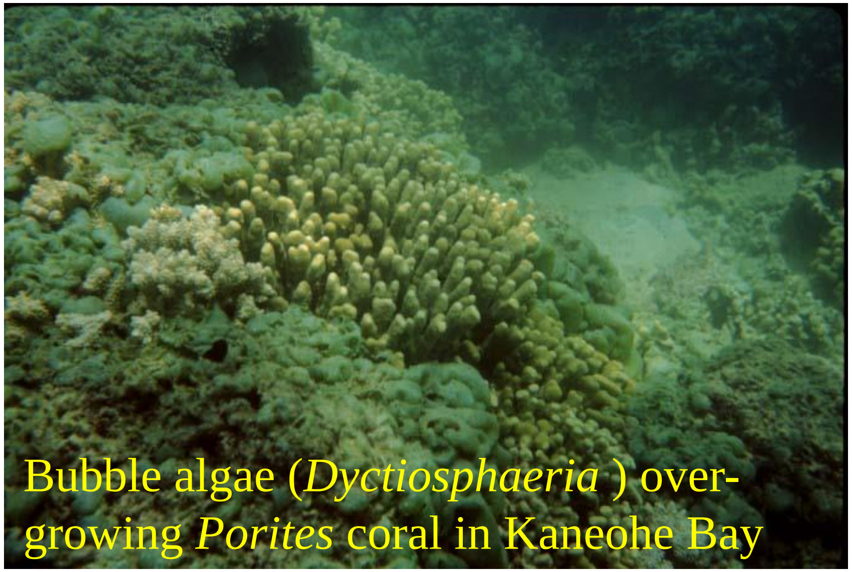
There is potential for development of medicines from coral reef organisms

- The U.S. National Institutes of Health established a laboratory in Micronesia to research this potential
- Harbor Branch Oceanographic Institute's Biomedical Marine Research Division

http://www.hboi.edu/dbmr/dbmr_home.html

Many human activities threaten coral reefs

- Sediments carried by rivers can cover and kill the corals
- Excess nutrients increase the growth of algae on the surface of the corals, increasing mortality



Bubble algae (*Dyctiosphaeria*) over-growing *Porites* coral in Kaneohe Bay

http:Dyctiosphaeria//emerald.ucsc.edu/~hyperwww/2.jpg

Sediment and nutrient runoff after heavy rains into Kaneohe Bay, HI

http://www.epa.gov/region09/islands/images/reef_kaneohe1.jpg

Marine Biological Zones

- Warming ocean temperatures can result in the loss of the algal partners from the corals, resulting in *coral bleaching*
- Increased incidence of fungal infections may be related to increased dust associated with desertification
- Future changes in ocean chemistry may inhibit the ability of corals to form skeletons

Caribbean sea fan infected with aspergillosis, caused by the fungal pathogen, *Aspergillis*

Bleached corals

http://ccma.nos.noaa.gov/images/biogeo/bleaching/figure1.jpg

http://www.uq.edu.au/news/images/media/DSCN0198-1.jpg

Kelp beds or forests

- Support diverse marine community, including sea urchins, lobsters, mussels, abalones, fishes, many other seaweeds, and sea otters
- **Kelp** are several genera of large brown algae, with leaf-like fronds, stems, and holdfasts which anchor to solid substrates

Figure 3.24 A Kelp Bed

ECOLOGY, Figure 3.24

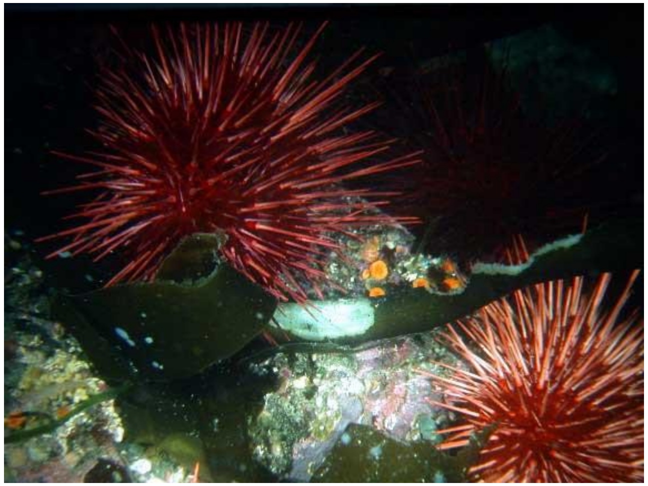
Marine Biological Zones

http://www.kintera.org/atf/cf/%7B1032ABCB-19F9-4CB6-8364-2F74F73B3013%7D/otter_withurchin_big.jpg

Kelp abundance influenced by interactions among various organisms

- Grazers such as sea urchins can reduce kelp abundance
- Urchin abundance is tied to predation by sea otters, while sea otter abundance is in turn related to orca and human predation

http://animals.nationalgeographic.com/staticfiles/NGS/Shared/StaticFiles/animals/images/primary/sea-otter.jpg



http://www.reefkeeping.com/issues/2003-11/rs/images/image001.jpg http://www.oceansatlas.org/unatlas/projectmanager/atlas_cd/cds_upload/1022781366931_sg_conch_noaa.jpg

Marine Biological Zones

Seagrass beds

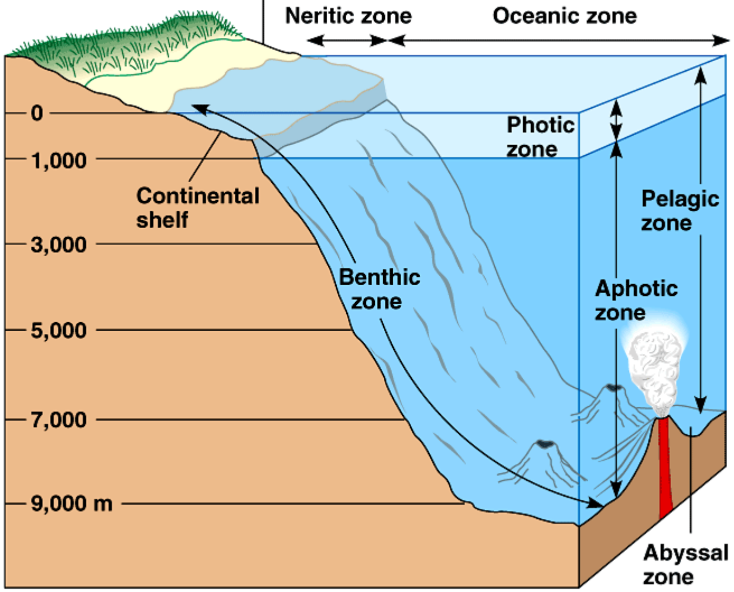
- Submerged beds of flowering plants (not related to grasses), in subtidal marine sediments of mud or fine sand
- Algae and animals (**epiphytes**) grow on plants, and larval stages of some organisms, such as mussels, depend on them for habitat
- Nutrients from upstream agricultural activities can increase algal growth in seagrass beds

http://farm1.static.flickr.com/212/513686453_32d9ee63b2.jpg?v=0

Marine Biological Zones

Pelagic zone

- Open ocean beyond continental shelves
- **Photic zone** supports highest densities of organisms, extends to about 200 m depth
- Below photic zone (**aphotic zone**), energy is supplied by falling detritus



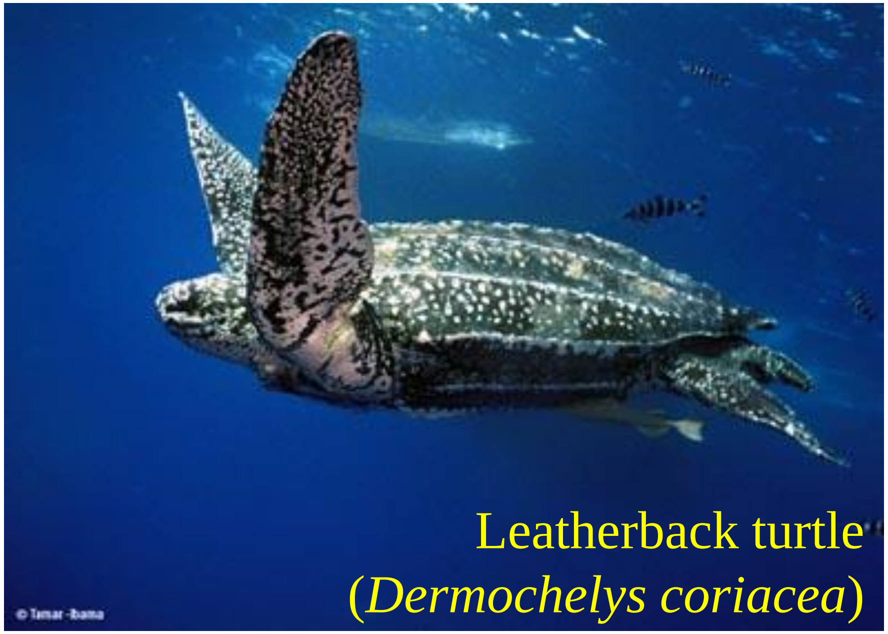
Male mahi-mahi, doradao or dolphinfish (*Coryphaena hippurus*) in blue water

http://www.brianskerry.com/portfolios/bluewater/1.jpg http://www.mbari.org/news/news_releases/2007/dosidicus-images/dosidicus6-350.jpg

Marine Biological Zones

Organisms in pelagic zone include:

- **Nekton** (swimming organisms capable of overcoming ocean currents) — fish, mammals, sea turtles, squid, octopus



Leatherback turtle
(*Dermochelys coriacea*)

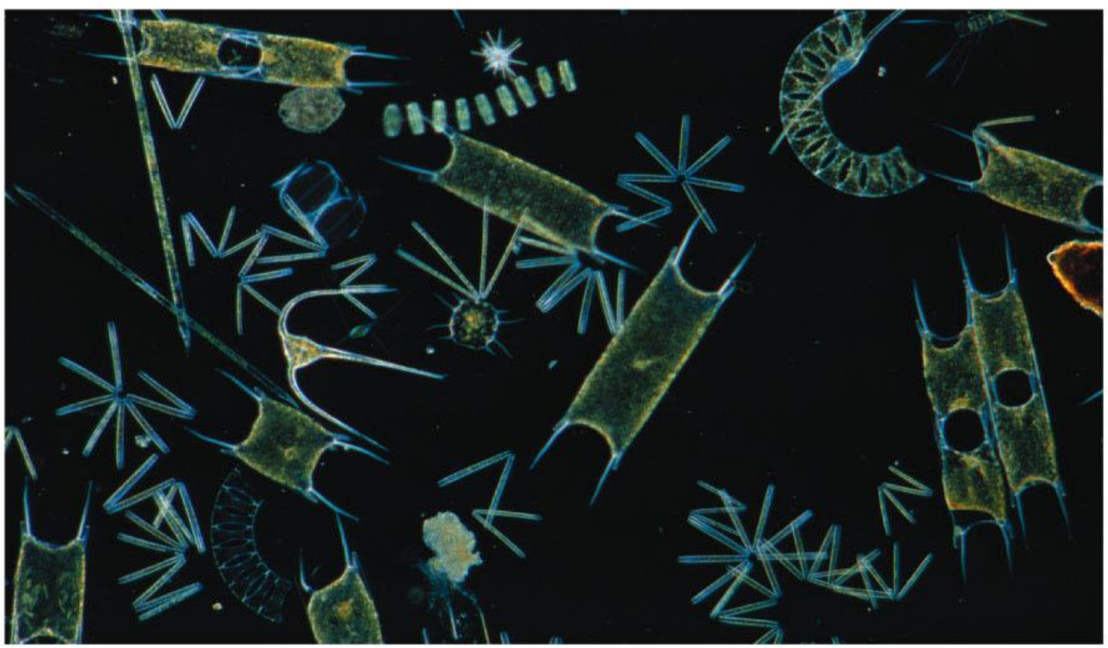
http://scienceblogs.com/deepseanews/2008/08/why_do_leatherback_turtles_div.php


Humboldt squid
(*Dosidicus gigas*)

Marine Biological Zones

- **Planktonic** (drifting) organisms
  - **Phytoplankton** — green algae, diatoms, dinoflagellates, and cyanobacteria
  - **Zooplankton** — protists (e.g., ciliates), crustaceans (e.g., copepods and krill), and jellyfishes

(A) Marine phytoplankton



(B) Marine zooplankton

Marine Biological Zones

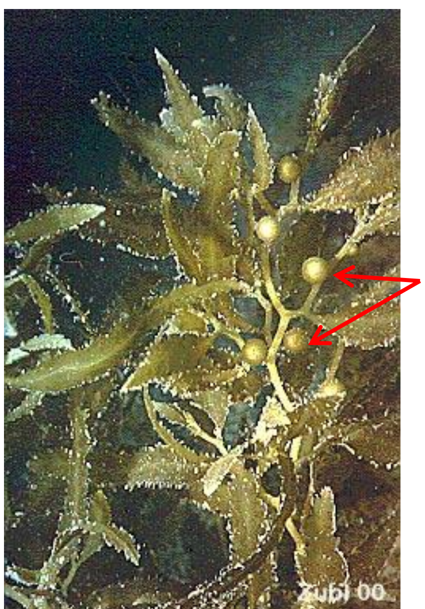
Pelagic seabirds, including albatross, petrels, fulmars, and boobies, spend most of their lives flying over open ocean waters, feeding on marine prey (fish and zooplankton) and detritus found on ocean surface

Black-browed Albatross, *Thalassarche melanophrys*

http://blather.net/abroad/antarctic/_MG_7970_albatross_skimming_500.jpg

Organisms in the pelagic zone must have ways to prevent sinking out of the photic zone, such as swimming

- The seaweed *Sargassum* has gas-filled bladders to keep it afloat. It forms large floating islands that are habitat for other organisms



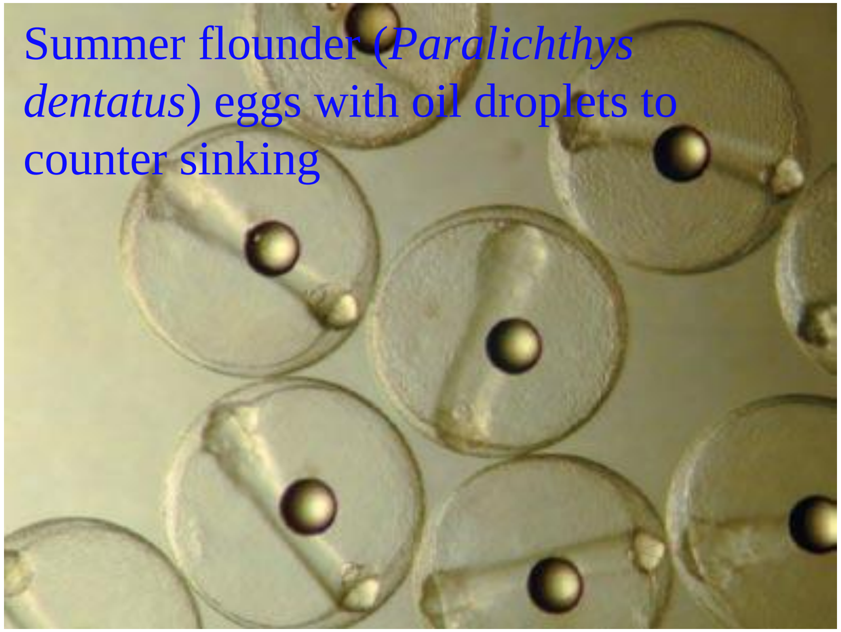
Gas-filled bladders

http://www.starfish.ch/photos/plants-Pflanzen/Sargassum.jpg

http://www.safmc.net/Portals/0/Sargassum/Sargassum_Ross4.jpg

Some plankton retard sinking by changing chemical composition to alter density relative to sea water

- Body shapes and projections can also slow sinking



http://www.ext.vt.edu/pubs/seafood/600-050/fig2.jpg

Marine Biological Zones

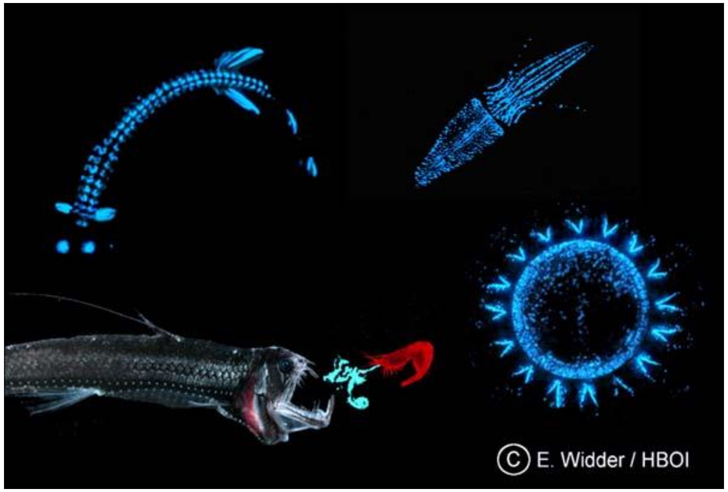
Below photic zone, temperatures drop and pressure increases

- Crustaceans such as copepods graze on rain of falling detritus from photic zone
- Crustaceans, cephalopods, and fishes are the predators of the deep sea

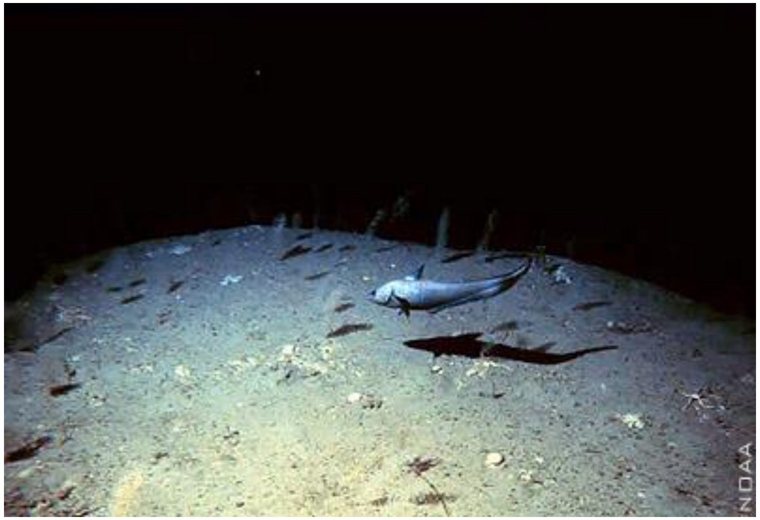
http://tolweb.org/tree/ToLimages/eledonellaFem.jpg

Ocean bottoms (**benthic zone**)

- Sparsely populated, with temperatures near freezing, and very high pressure
- Sediments are rich in organic matter, contain bacteria, protists, and sea worms
- Sea stars and sea cucumbers graze ocean floor or filter food from water
- Bioluminescence is also used by benthic predators to lure prey



http://oceanexplorer.noaa.gov/explorations/02sab/background/biolum/media/biolum_600.jpg

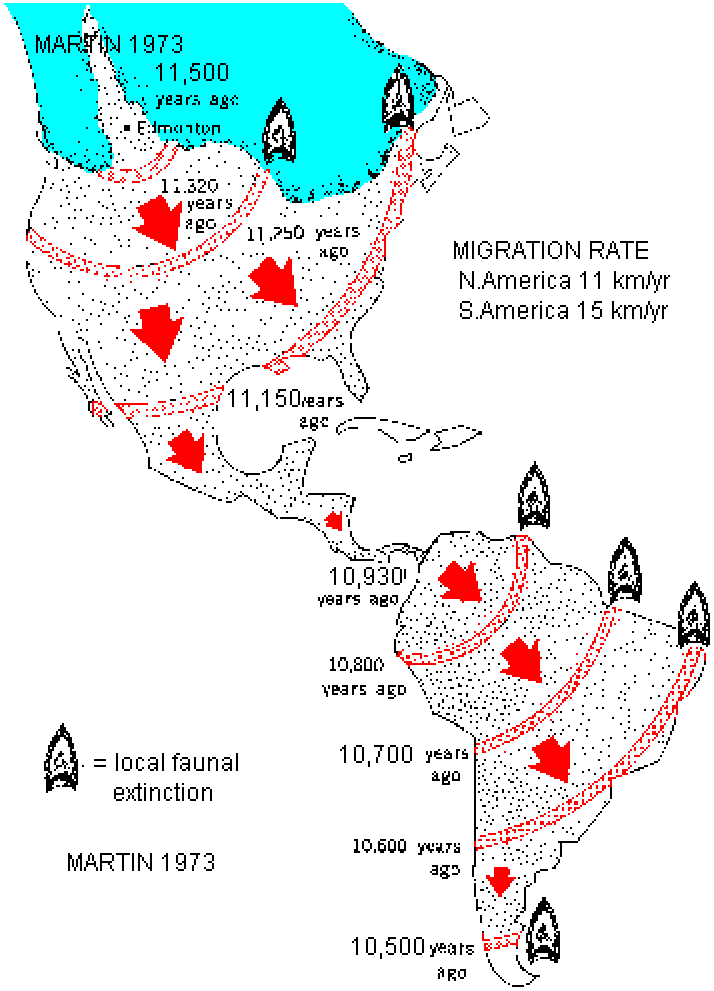


http://marinebio.org/i/deepsea.jpg

Case Study Revisited: The American Serengeti: Twelve Centuries of Change in the Great Plains

Paul Martin noted correspondence between extinction events on several continents and the arrival of humans on those continents (Martin 1984, 2005)

- The rapidity of extinctions, and number of large animals, suggested to him that hunting by humans caused the extinctions



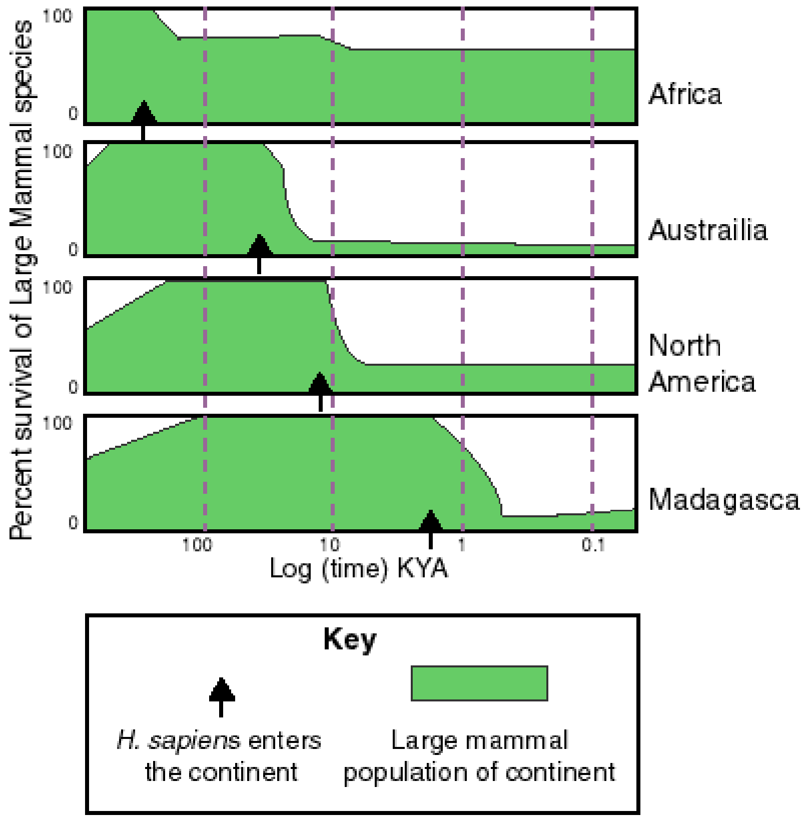
http://www.geo.arizona.edu/palynology/geos462/overkill.gif

Case Study Revisited: The American Serengeti: Twelve Centuries of Change in the Great Plains

This "overkill hypothesis" has received increasing support

- Archeological evidence shows that humans butchered some of these extinct animals
- On small islands, human arrival and extinctions coincided
- Humans also brought diseases as well as predators such as rats and snakes

Humans evolved with megafauna in Africa with little extinctions, but not on other continents which show high extinctions

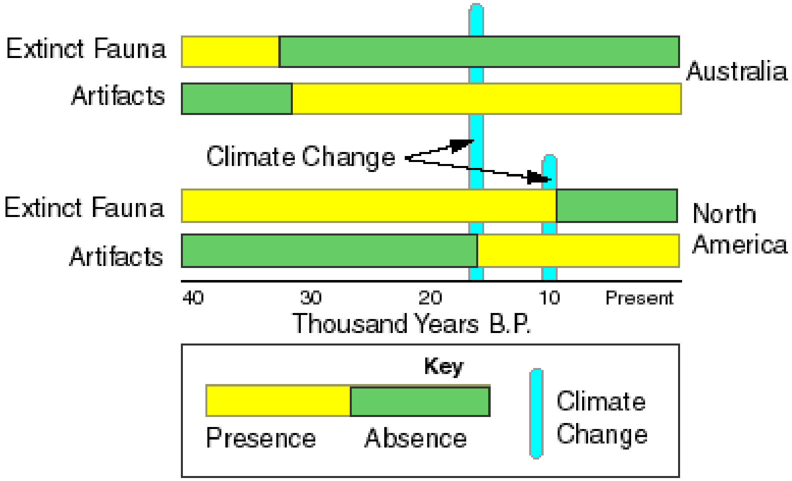


http://en.wikipedia.org/wiki/Pleistocene_extinctions

Case Study Revisited: The American Serengeti: Twelve Centuries of Change in the Great Plains

Other mechanisms may also have been involved

- These include spread of diseases by humans and dogs, climate change, and the loss of some species that depended on others, such as mastodons
- A combination of factors probably contributed to the extinctions



Extinctions occur in relation to human artifacts regardless of climate change in Australia (support overkill hypothesis), but appear linked to climate change in North America (refutes overkill hypothesis)

http://en.wikipedia.org/wiki/Pleistocene_extinctions

Case Study Revisited: The American Serengeti: Twelve Centuries of Change in the Great Plains

Some large mammals did not go extinct.

- Bison, elk, pronghorn, and deer roamed Great Plains and continued to be hunted by humans
- Humans began to use more fire to manage habitat and for small-scale agriculture

http://www.animalstwist.com/wp-content/uploads/2008/05/bison.jpg

http://www.nwf.org/ecards/images/pronghorn.jpg

Case Study Revisited: The American Serengeti: Twelve Centuries of Change in the Great Plains

Between 1700 and 1900, human activities caused profound changes.

- Horses were brought by Spanish, facilitating bison hunting
- Arrival of Euro-Americans and their conflicts with Native Americans led to the near extinction of bison

ECOLOGY, Figure 3.27

Case Study Revisited: The American Serengeti: Twelve Centuries of Change in the Great Plains

After 1850, mechanized agriculture and domesticated animals transformed the landscape.

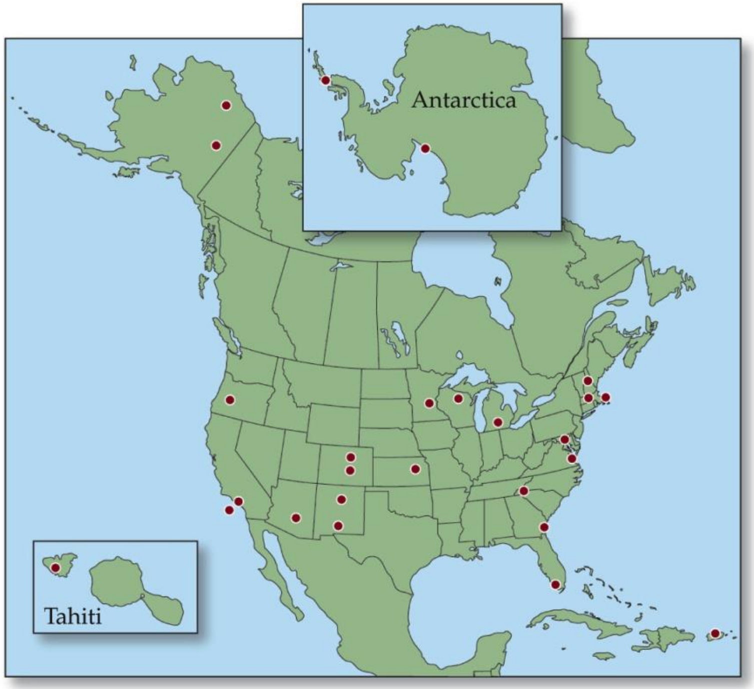
- Today only 1% of the eastern tallgrass prairie remains
- Overgrazing and unsustainable agricultural practices led to the "Dust Bowl" of the 1930s – drought and windstorms resulted in substantial losses of fertile topsoil

http://www.paulnoll.com/Oregon/Birds/ecology-grasslands.jpg

Connections in Nature: Long-Term Ecological Research

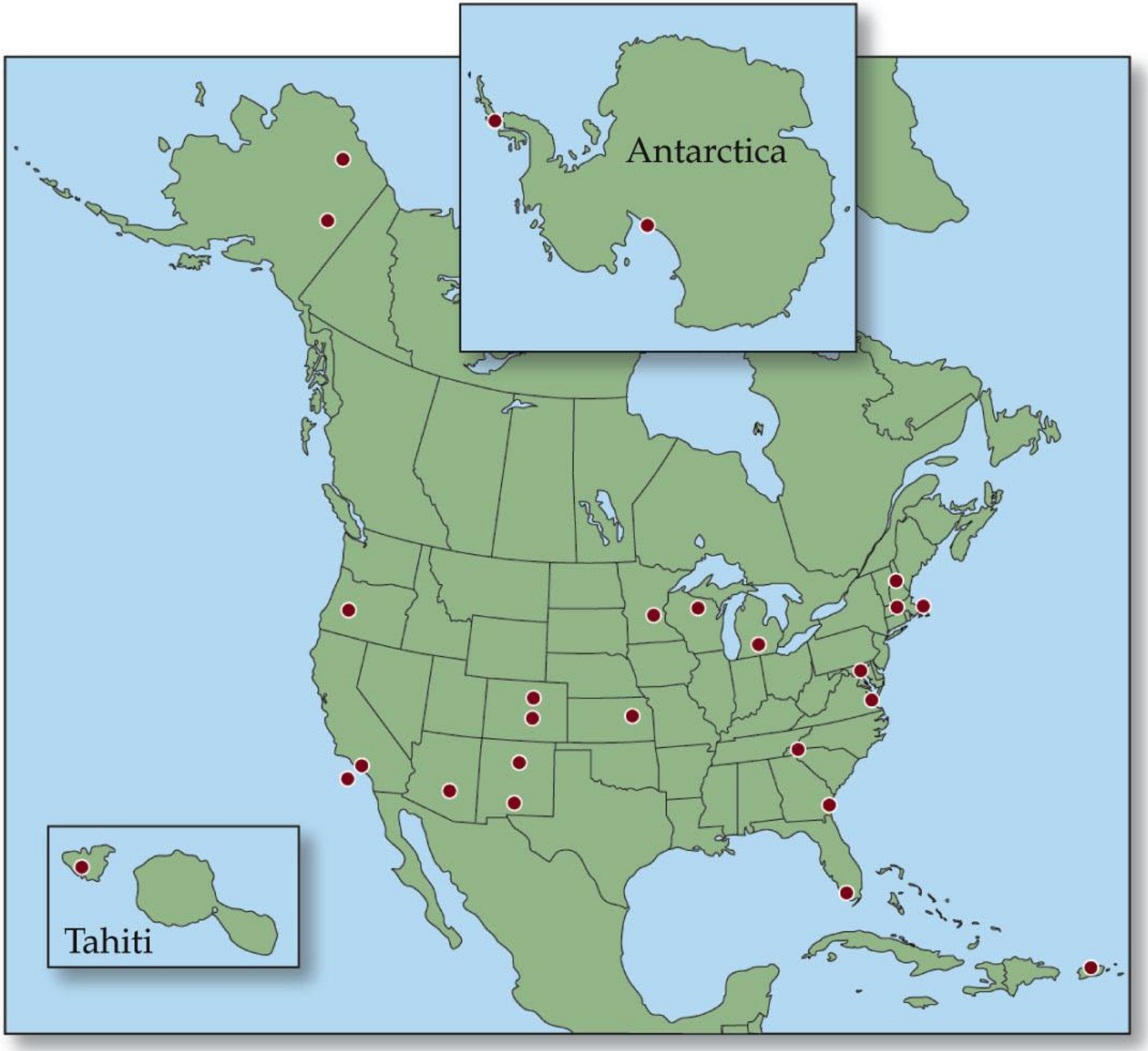
Long-term ecological research (LTER) sites

- Network of research sites to understand the effects of human activities on natural systems
- Established in 1980 by U.S. National Science Foundation (NSF)
- To provide knowledge necessary to conserve, protect, and manage ecosystems, their biodiversity, and services



ECOLOGY, Figure 3.28

Figure 3.28 Long-Term Ecological Research Programs



ECOLOGY, Figure 3.28

Konza Prairie LTER in Kansas is in a remnant of tallgrass prairie

- Research has focused on understanding the interaction of fire, grazing, and climate in this ecosystem
- Research on precipitation patterns has provided insights into possible effects of climate change

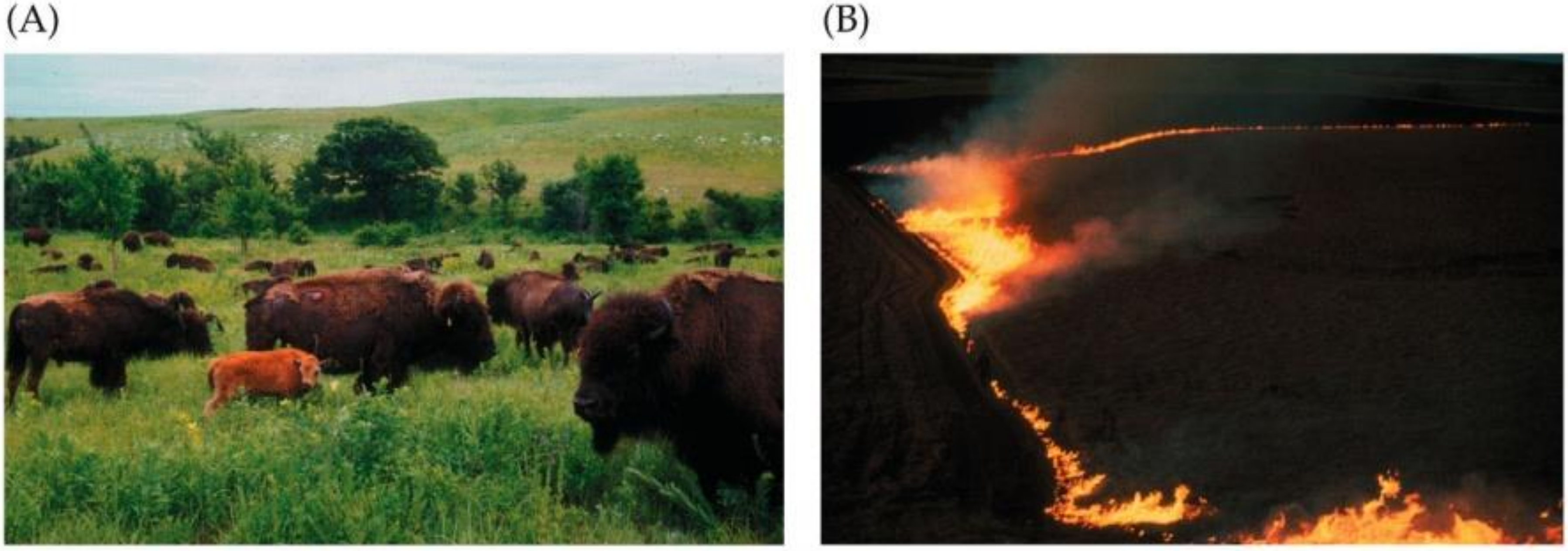


Figure 3.29 Research at the Konza Prairie LTER Site