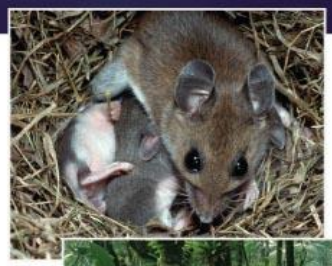
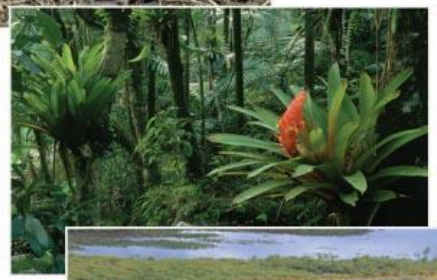
Ecology Unit: Chapter 52-56

Chapter 52- Introduction to Ecology and Biosphere

Organismal ecology

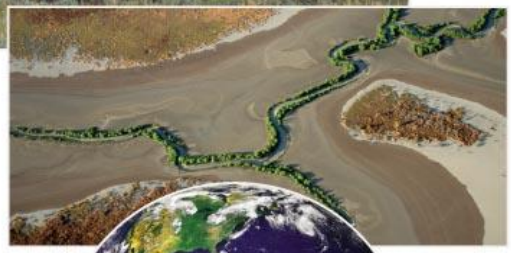


Population ecology



Community ecology

Ecosystem ecology



Landscape ecology

Global ecology

<u>Ecology</u> is the scientific study of the interactions between organisms and the environment.

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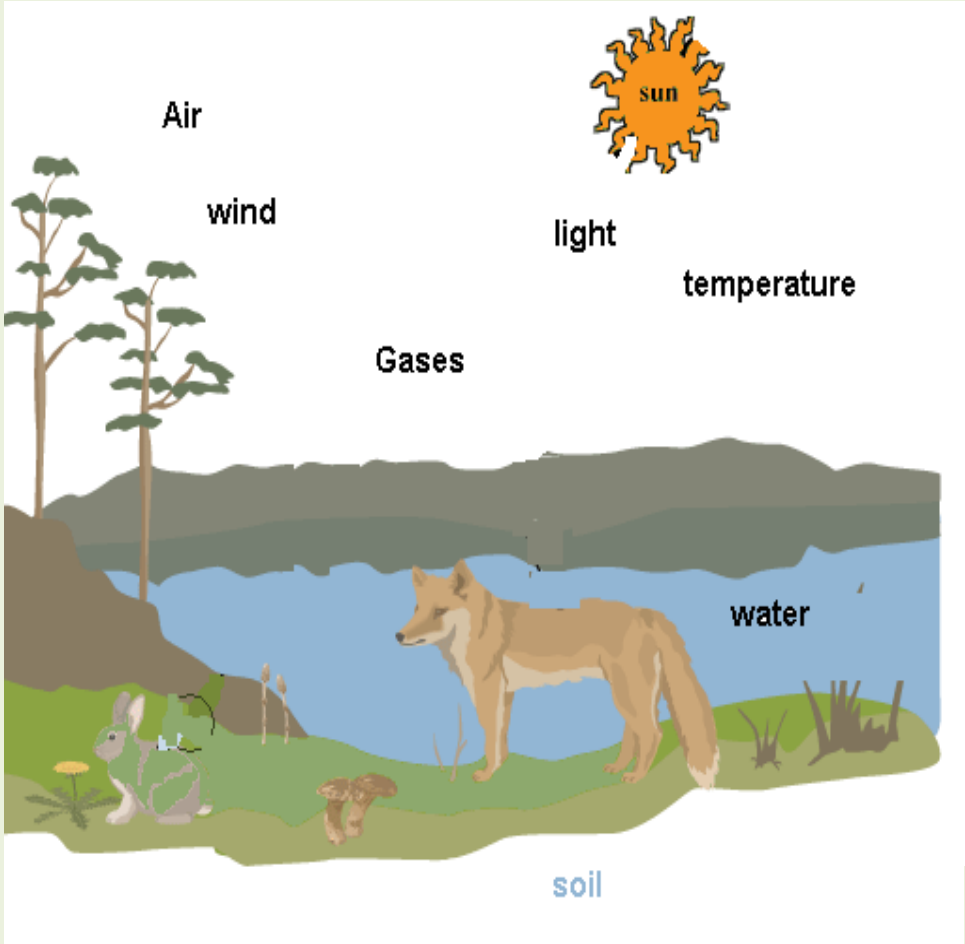
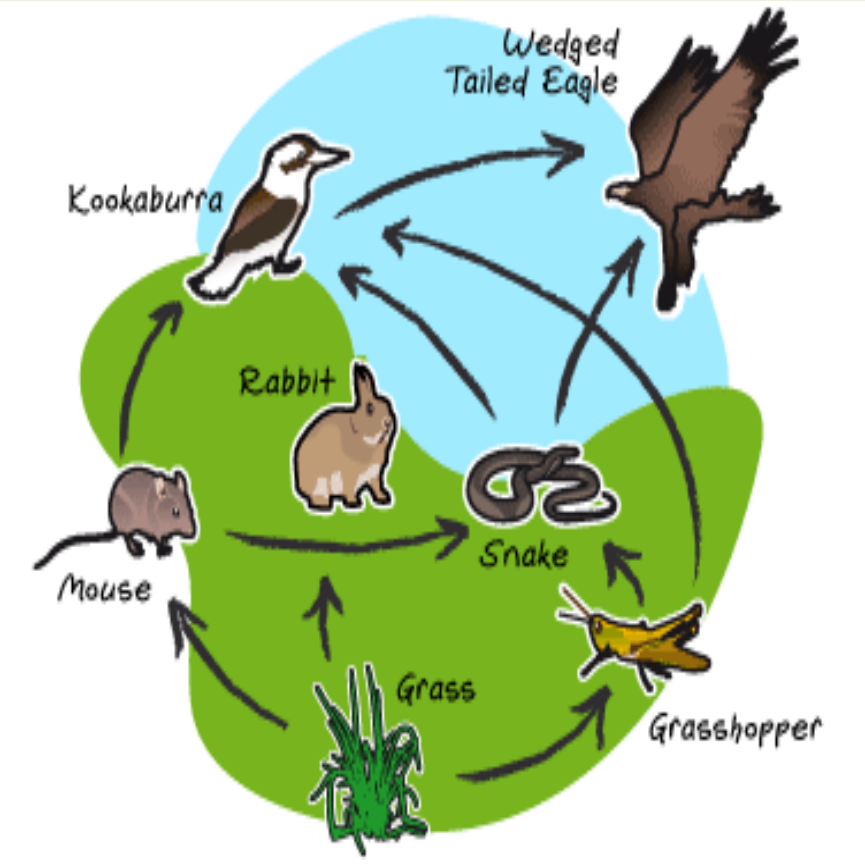
Environmental factors

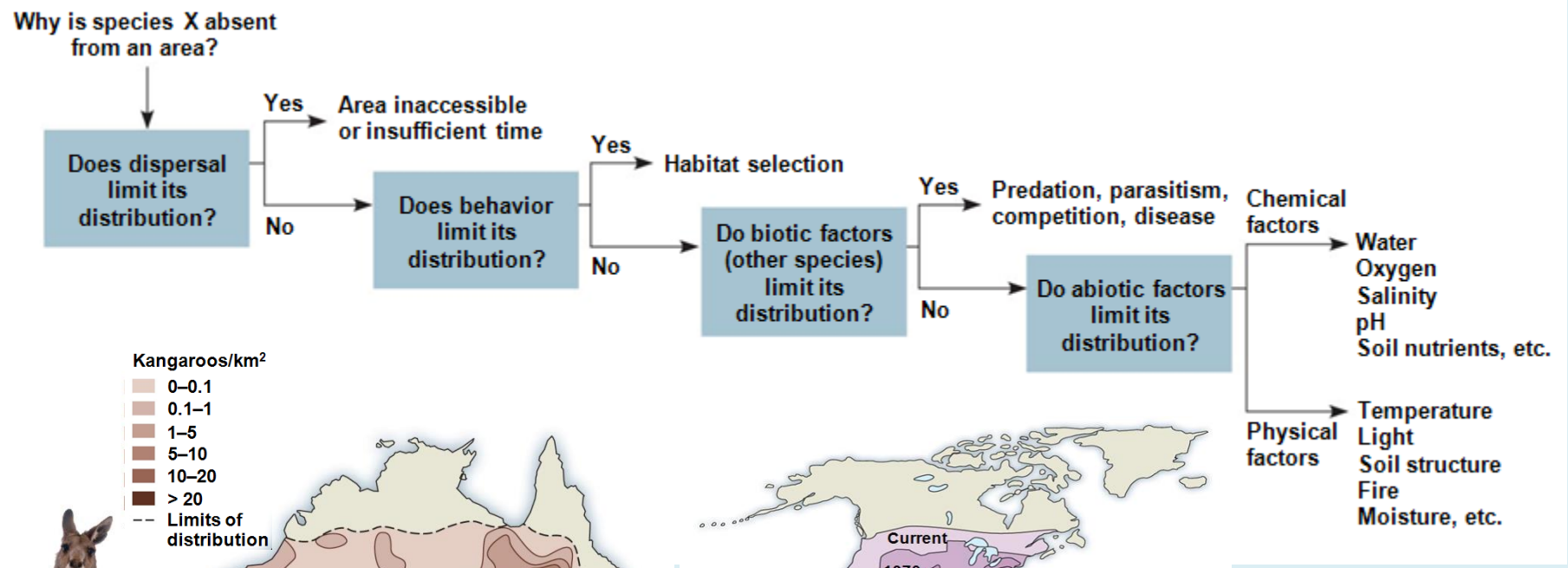
- <u>Abiotic factors</u>

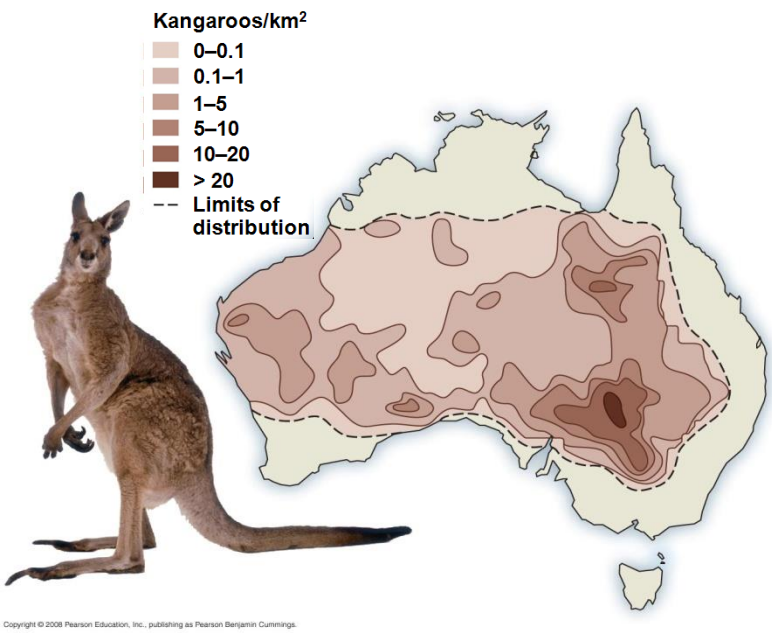


- <u>Biotic Factors</u>



Studying Population Dispersal and Distribution





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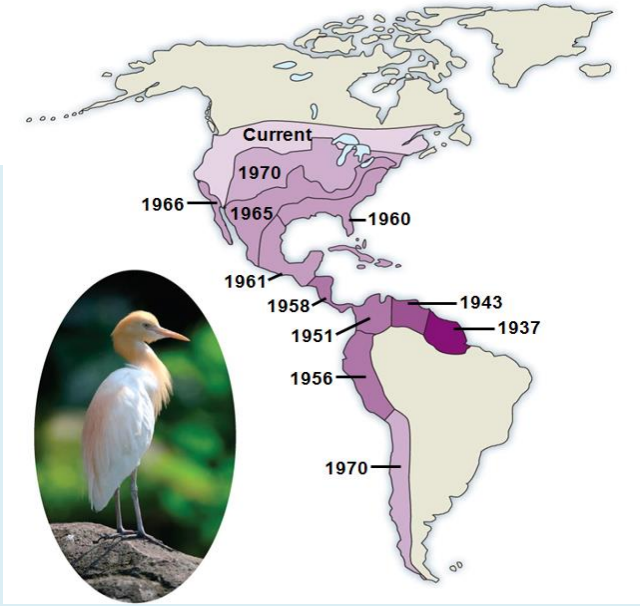
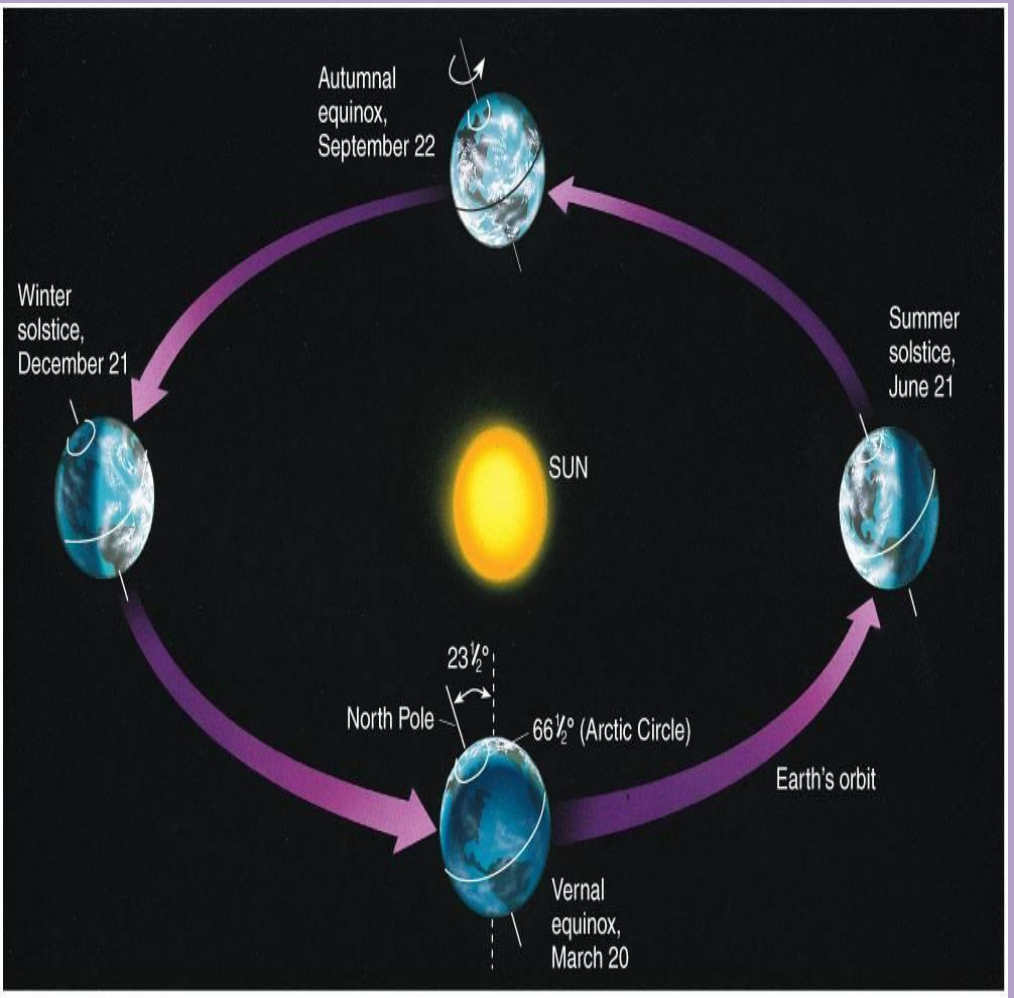


Seasons, Circulation, Biomes



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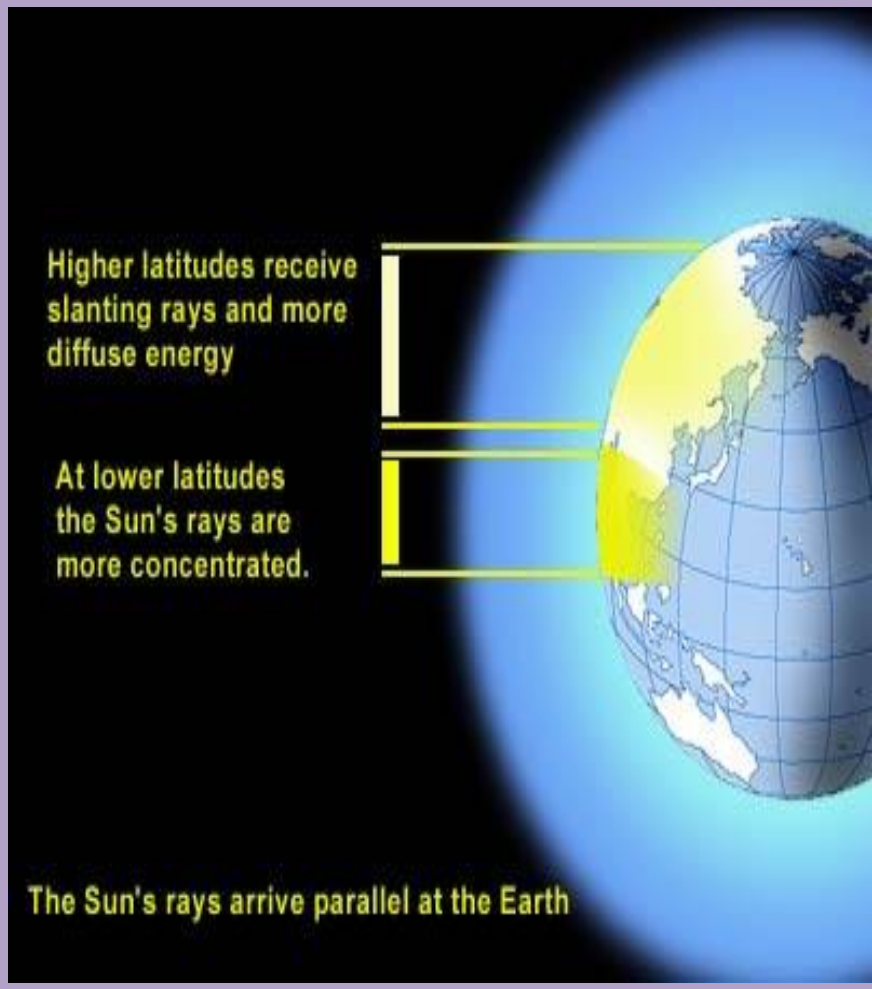
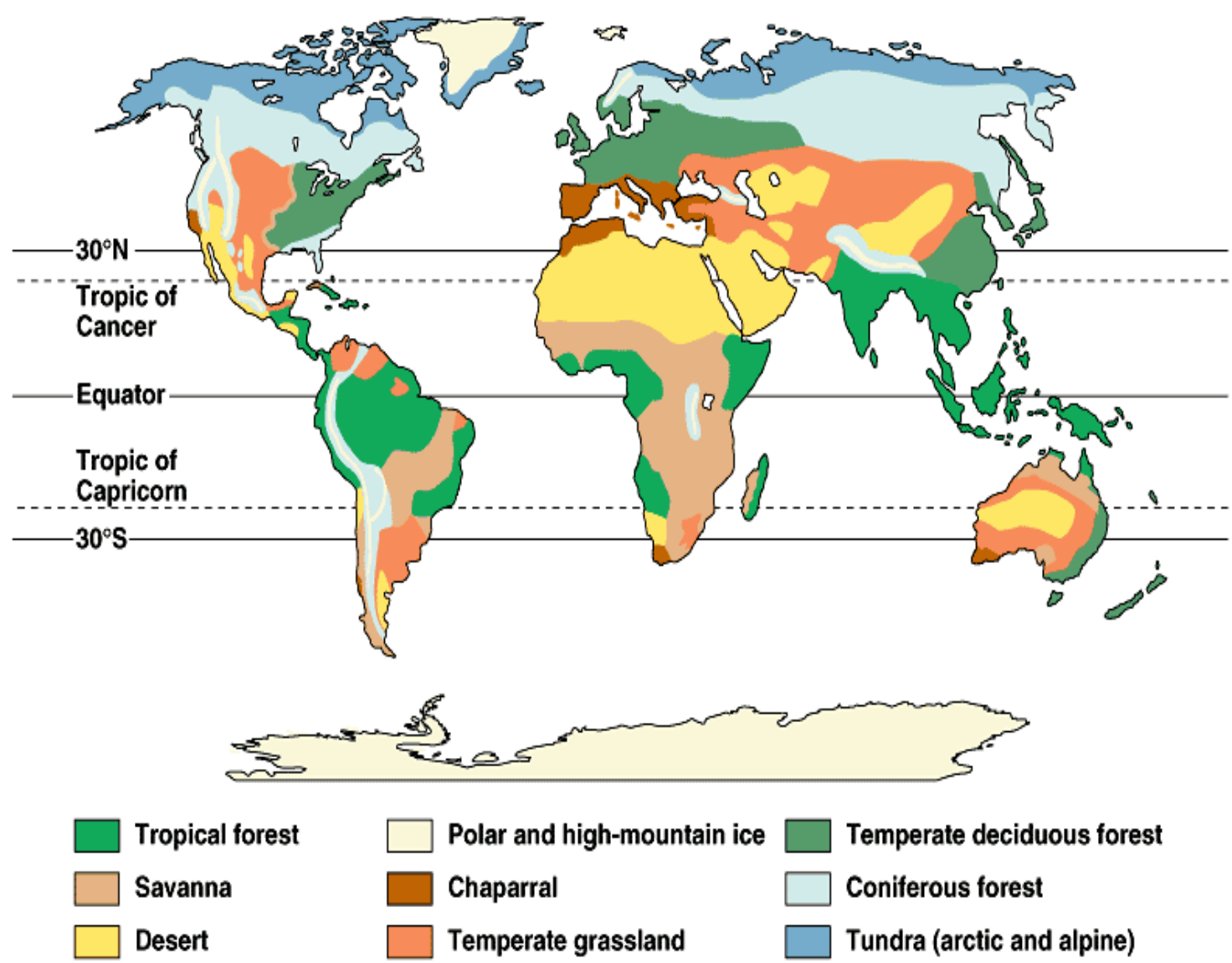
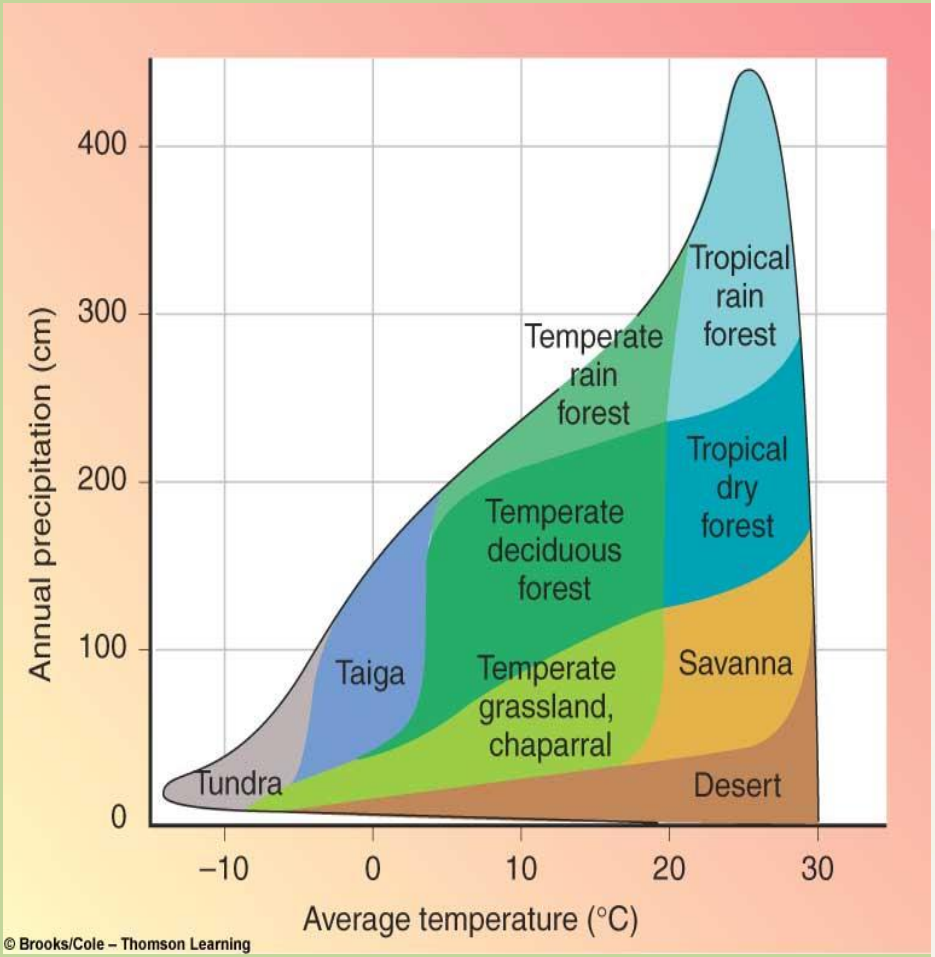
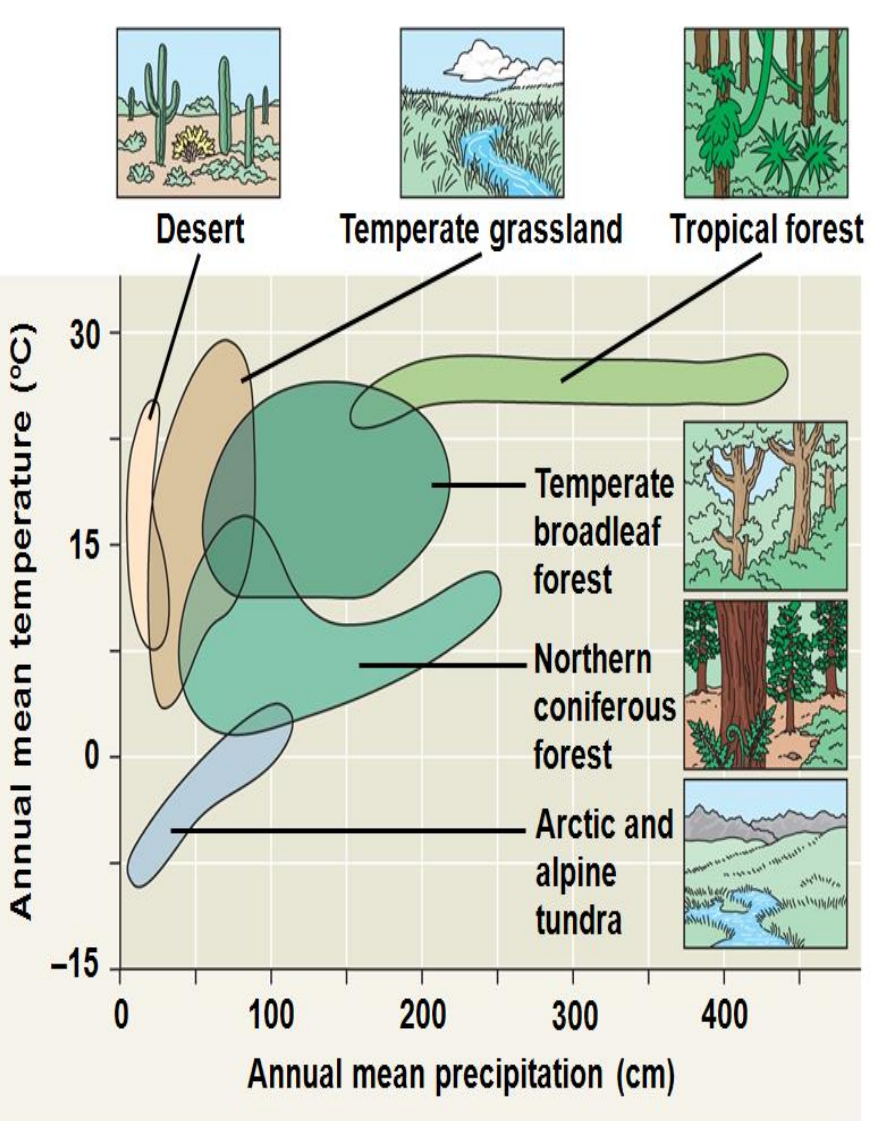


Earth's Biomes



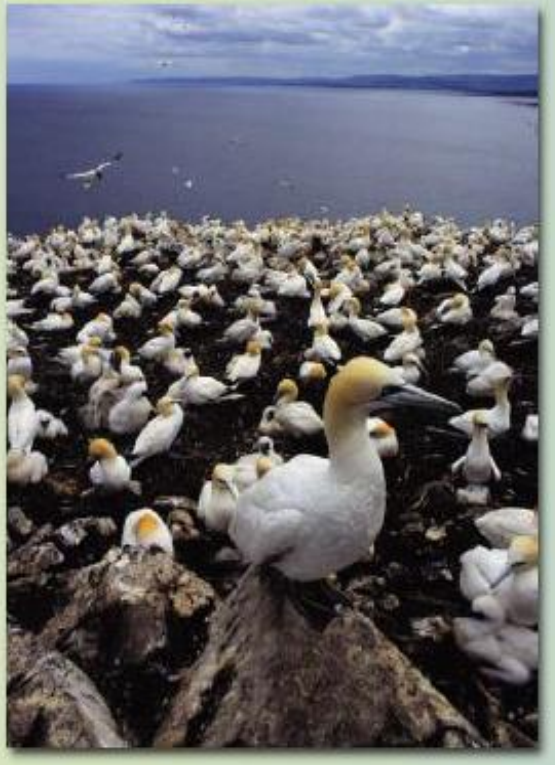
Using Precipitation And Temperature To Identify Biomes





Life takes place in populations

- Population
  - group of individuals of <u>same</u> species in <u>same</u> area at <u>same</u> time



Chapter 53- Population Ecology

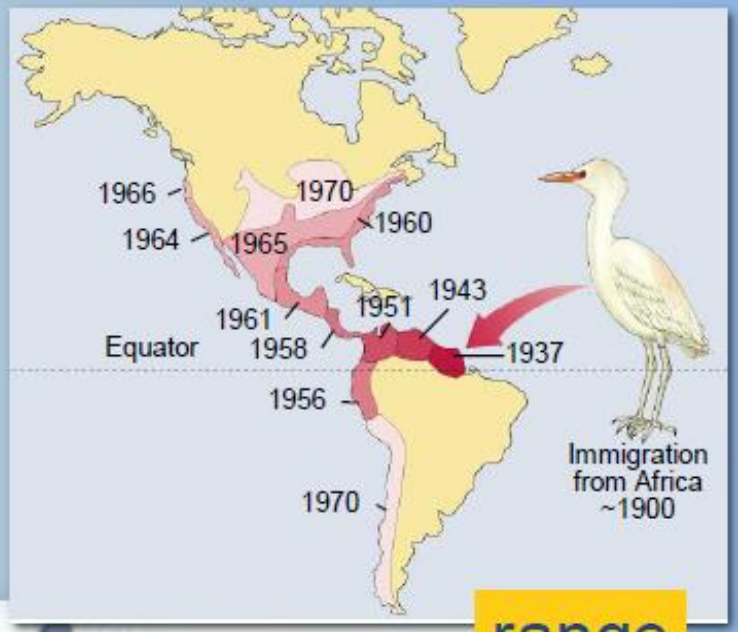
- rely on same resources
- interact
- interbreed

Why Population Ecology?

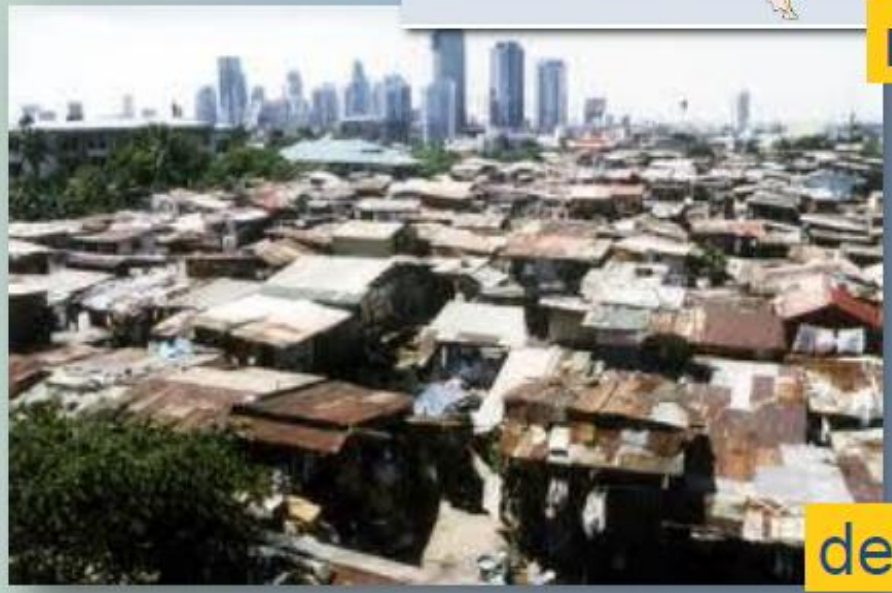
- Scientific goal
  - understand the factors that influence the size of populations
    - general principles
    - specific cases
- Practical goal
  - management of populations
    - increase population size
      - endangered species
    - decrease population size
      - pests
    - maintain population size
      - fisheries management
        - » maintain & maximize sustained yield

Characterizing a Population

- Describing a population
  - population range
  - pattern of spacing
    - density
  - size of population



range



density

Calculating Population Size and Density

- Count every individual
- Random sampling
- Mark-recapture method

CHANGES TO POPULATION SIZE

-Adding & removing individuals from a population

birth/ death

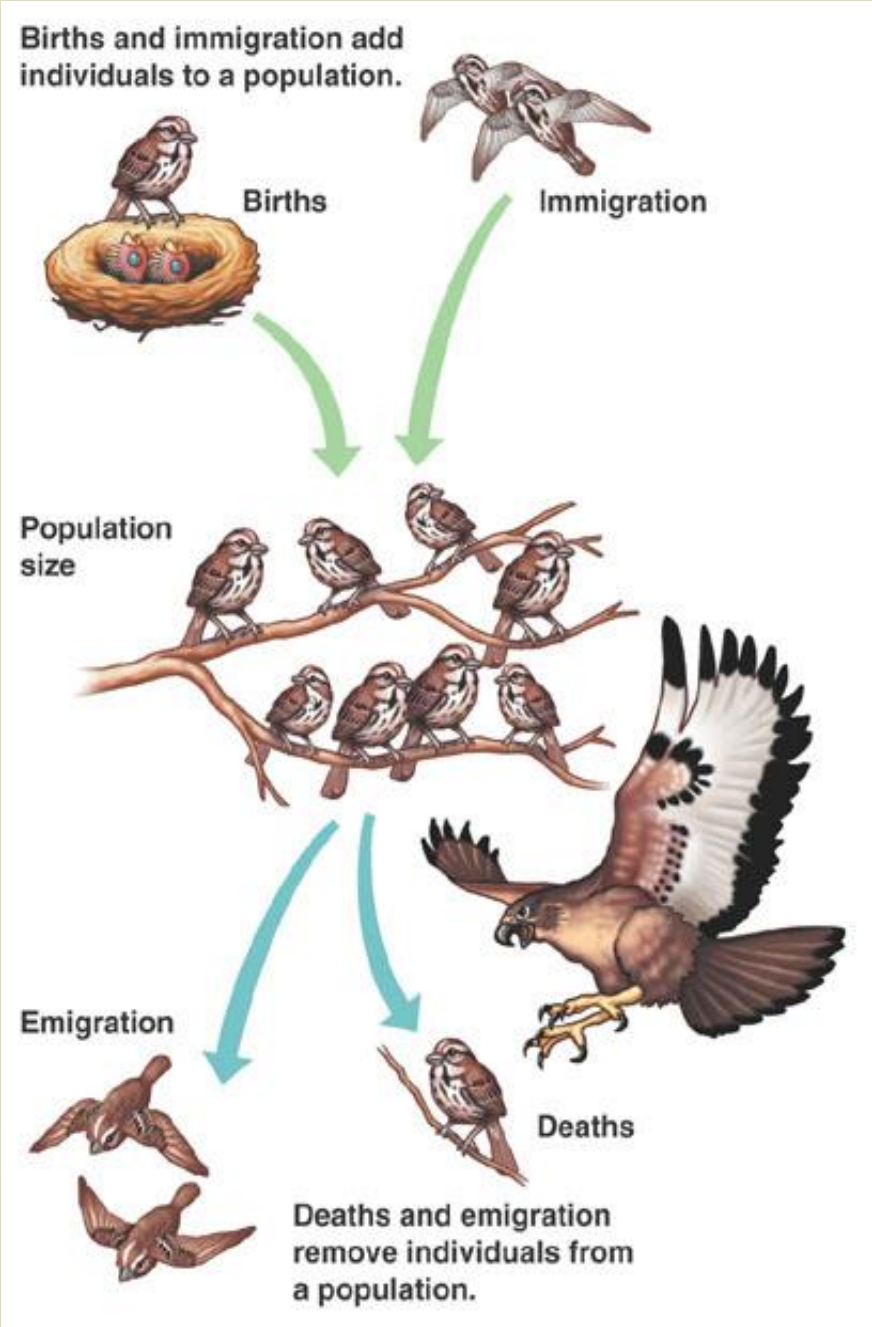
immigration

emigration

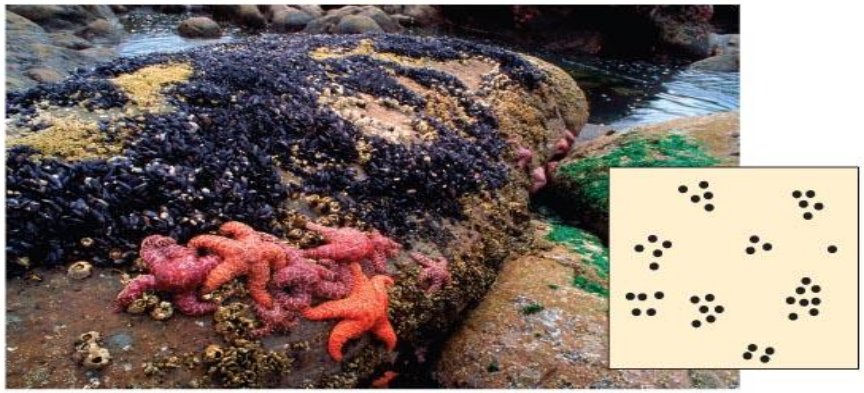
-Equation to Estimate Populations Size:

$N = mn / x$

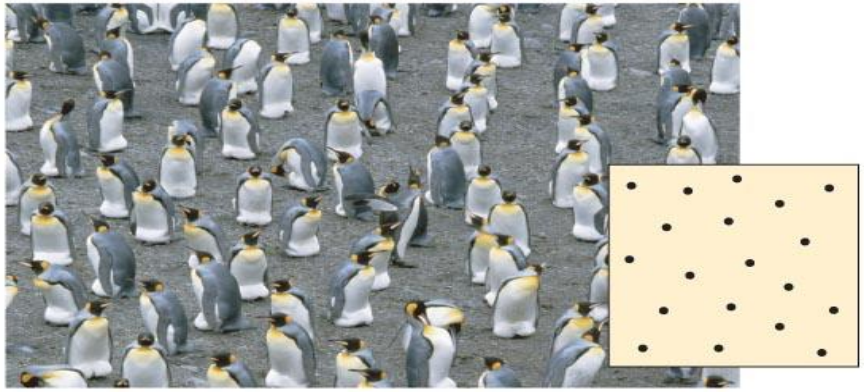
N= population size
m= # of individuals marked and released in the first sampling
n= total number of individuals recaptured
x= # of marked individuals recaptured in second sampling



Patterns of Dispersion

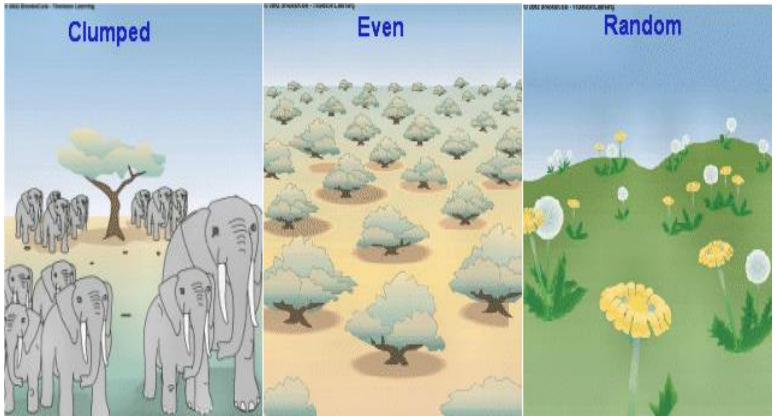


(a) Clumped-resource availability, mating capacity, effective survivor adaptation



(b) Uniform- territorial, lots of competition

(c) Random- absence of strong attractions or repulsions



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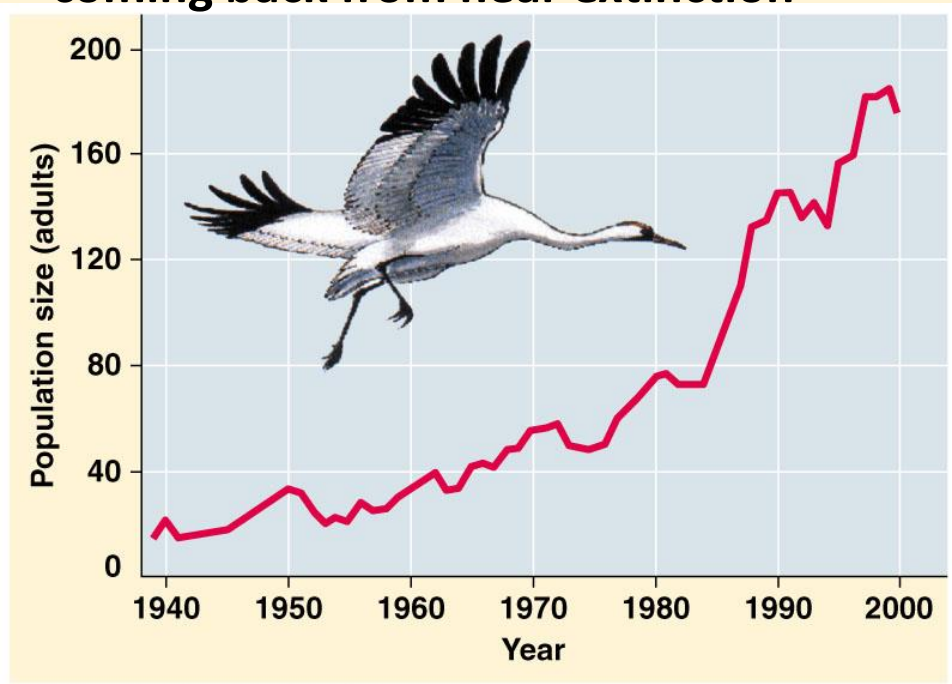
Growth rate

- Exponential growth (J shape)
  - characteristic of a population without limiting factors (ideal)
    - Ex. introduced to a new or unfilled environment
    - Ex. rebounding from a catastrophic event

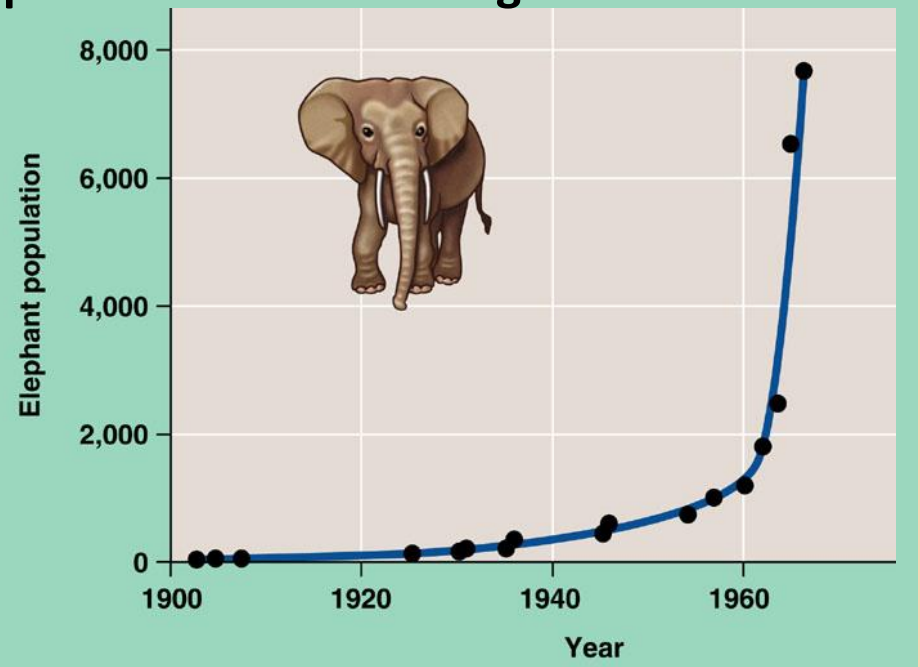
Whooping crane

coming back from near extinction



African elephant

protected from hunting

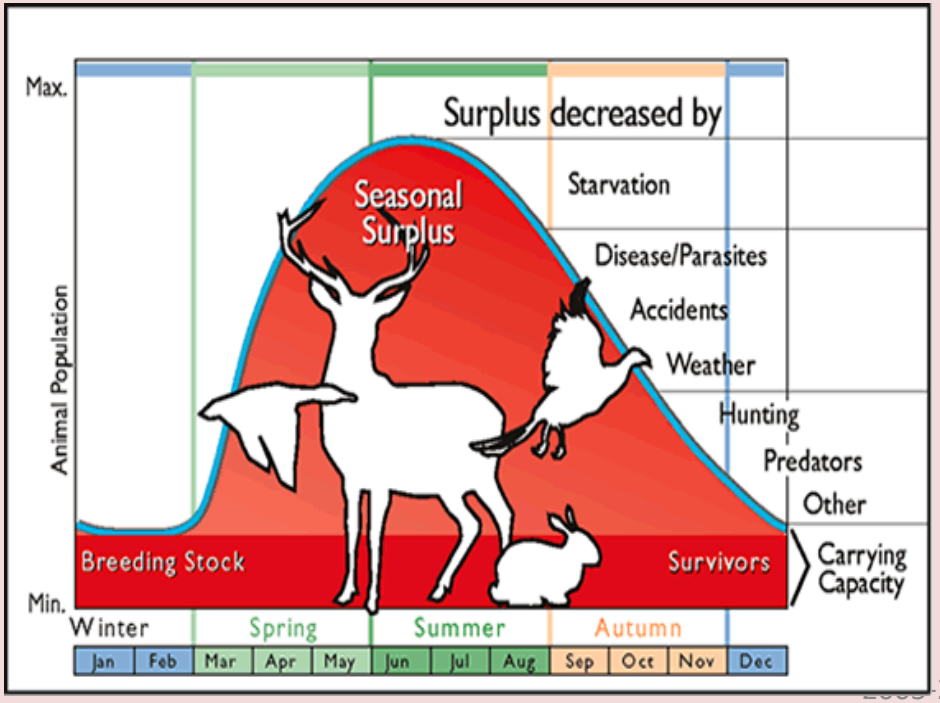


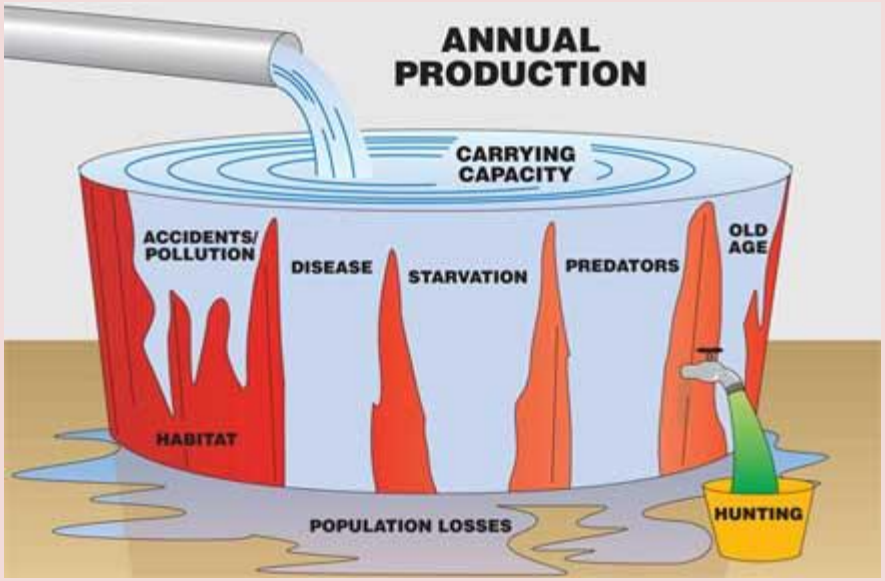
Population growth rates

- Factors affecting population growth rate
  - sex ratio
    - how many females vs. males?
  - generation time
    - at what age do females reproduce?
  - age structure
    - how females at reproductive age in cohort?

Carrying capacity

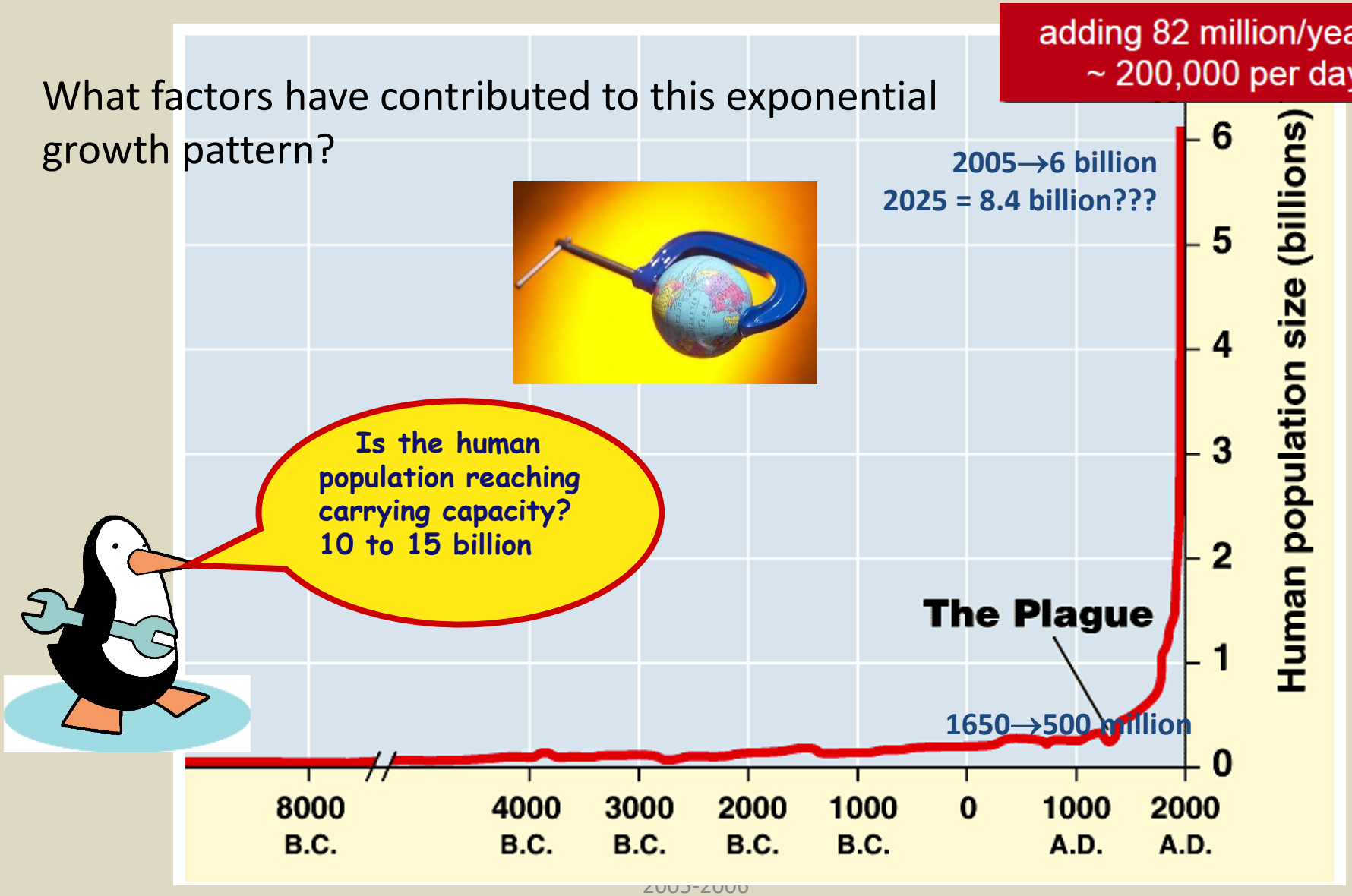
- Can populations continue to grow exponentially?
  - what sets limit? resources, predators, parasites
- Carrying Capacity (K)
  - maximum population size that environment can support with no degradation of habitat (not fixed; varies with changes in resources)



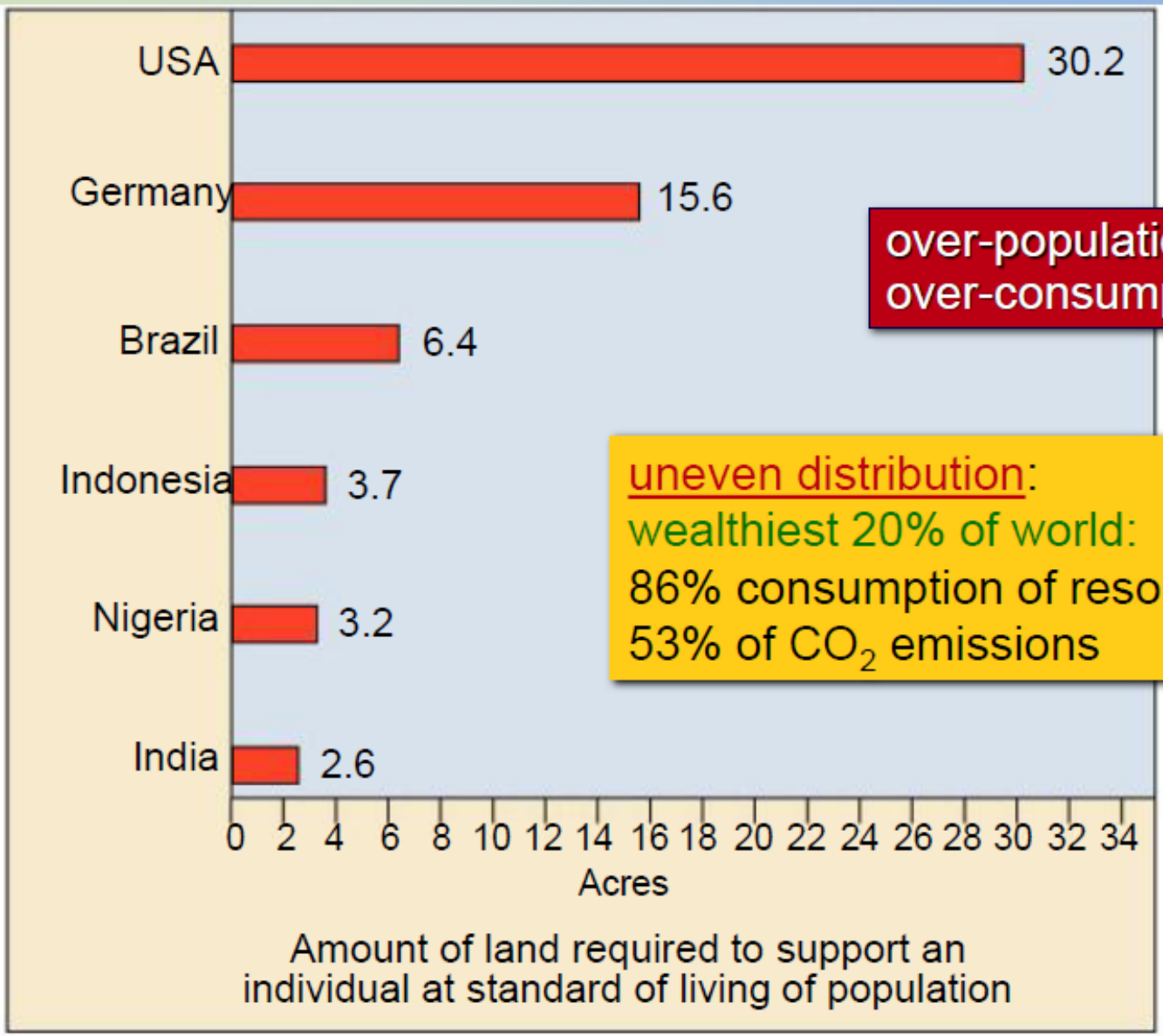


Human population

What factors have contributed to this exponential growth pattern?



Ecological Footprint



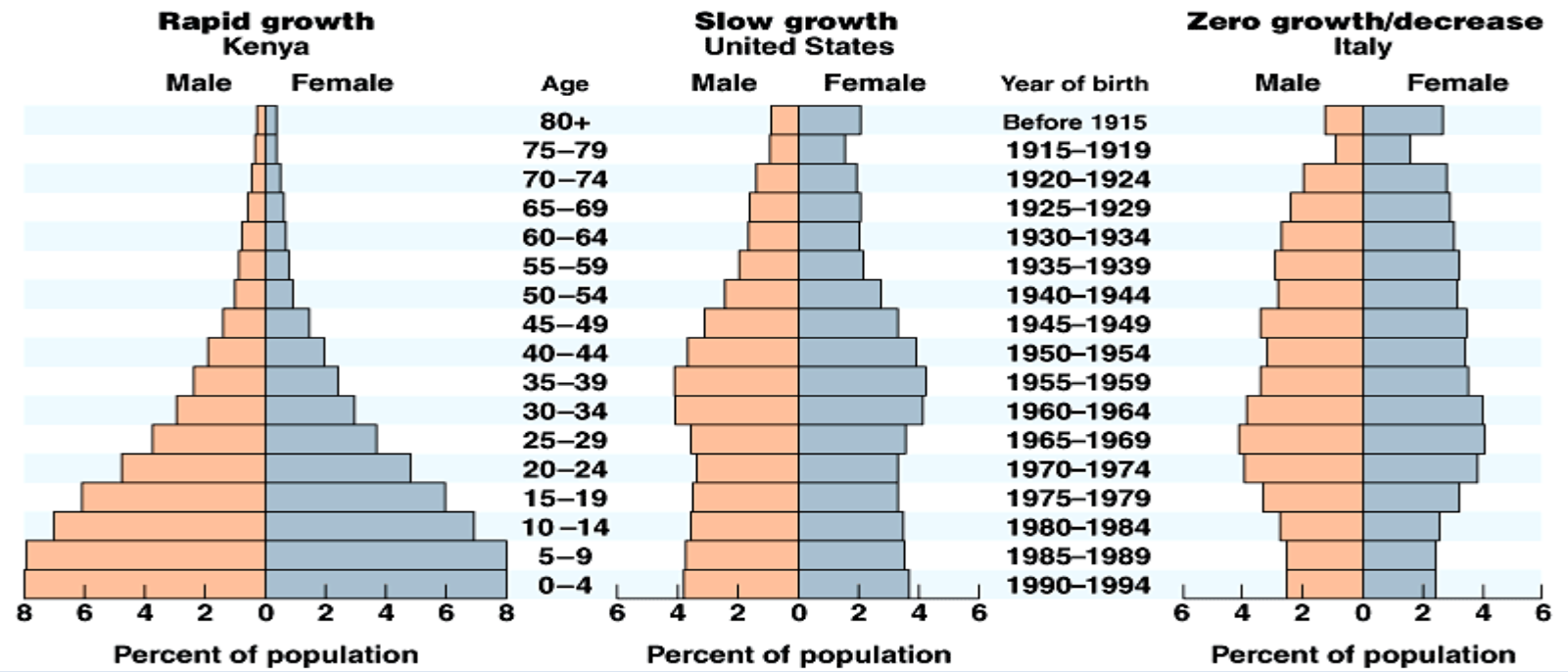
over-population or over-consumption?

uneven distribution:
wealthiest 20% of world:
86% consumption of resources
53% of CO_2 emissions

Age structure

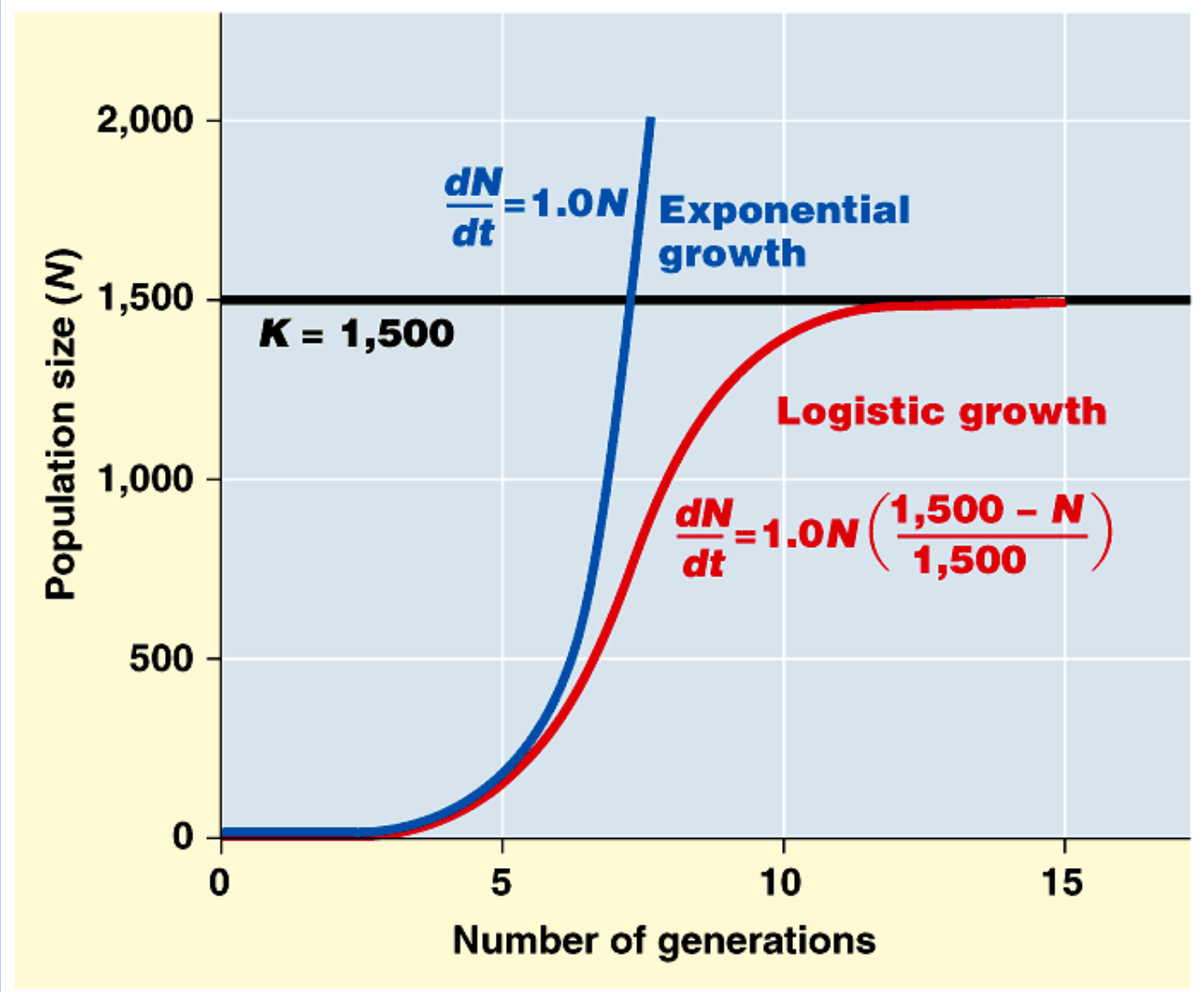
- Age structure diagrams can predict a population's growth trends
- They can illuminate social conditions and help us plan for the future
- Relative number of individuals of each age
- **Zero Population Growth** - same number enters as leaves the population
- Growth rate (r) = birth rate (b) - death rate (d)

  Population growth = rN (r = growth rate, N = original population size)

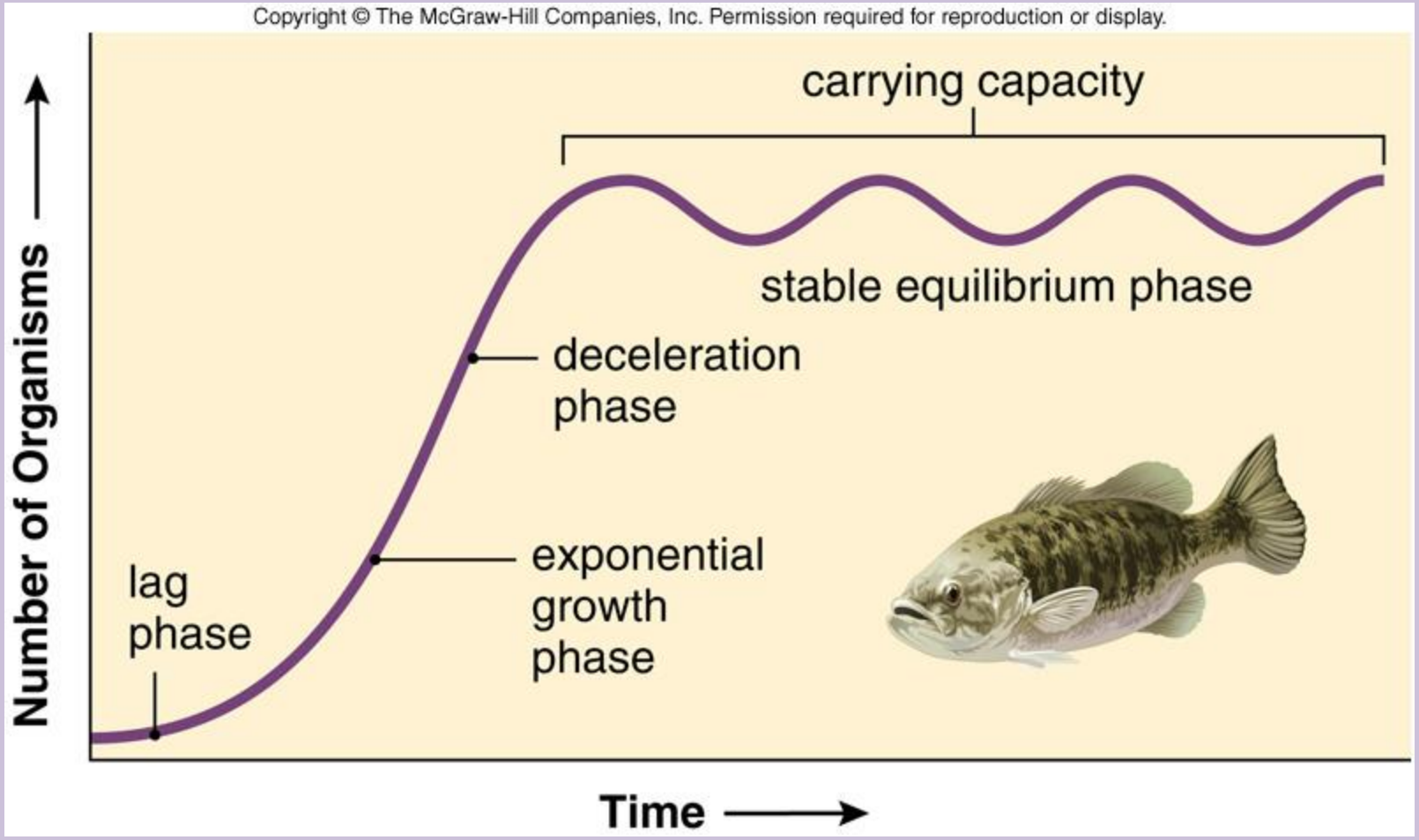


Model of growth

Decrease in rate of growth as reach carrying capacity (as N approaches K)



Logistic Growth Curve



Reproductive strategies

K-selection (logistic)	r-selection (exponential)
Live around K	Exponential growth
High prenatal care	Little or no care
Low birth numbers	High birth numbers
Good survival of young	Poor survival of young
Density-dependent	Density independent
ex. Humans, Primates	ex. Insects, weeds

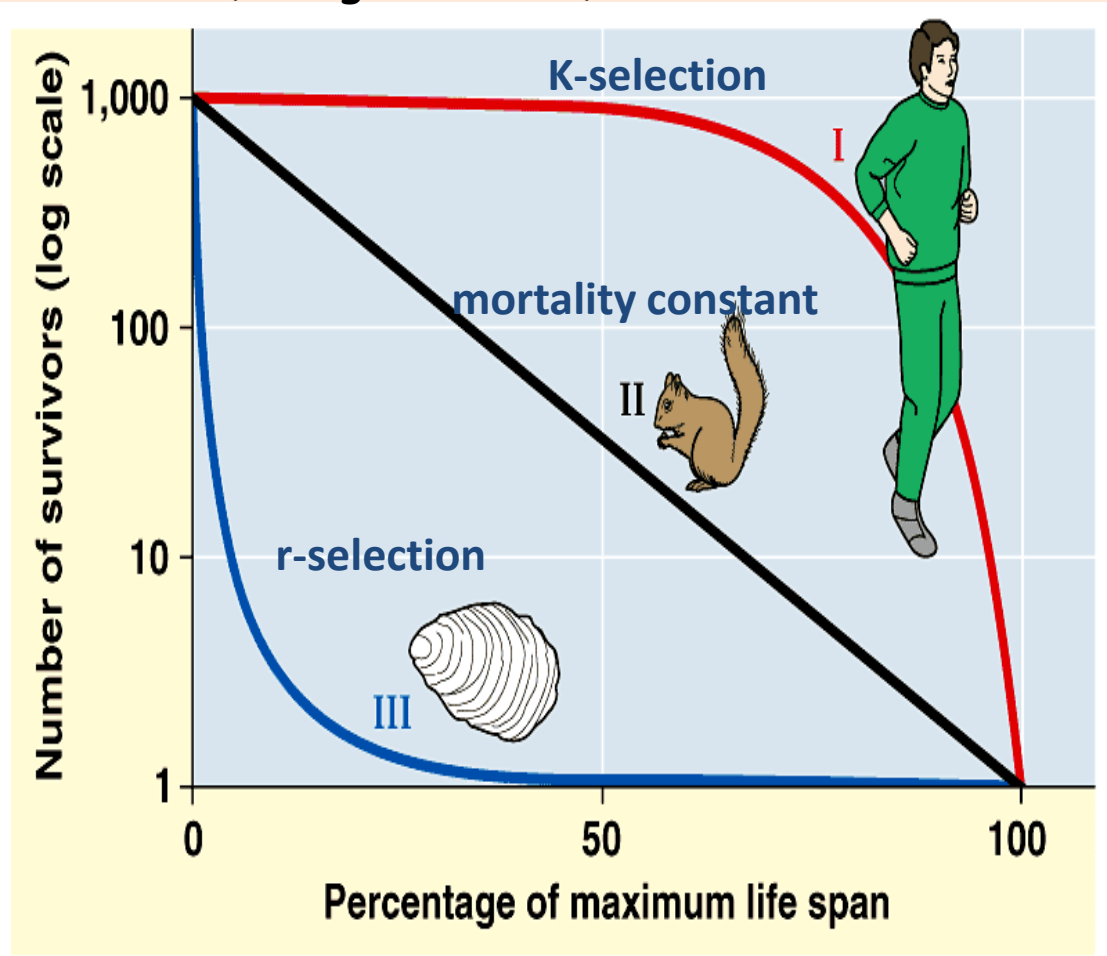
Different life strategies

K-selection, or density-dependent selection, selects for life history traits that are sensitive to population density (competition, disease)
r-selection, or density-independent selection, selects for life history traits that maximize reproduction (drought stress(

I. High death rate in post-reproductive years

II. Constant mortality rate throughout life span

III. Very high early mortality but the few survivors then live long (stay reproductive)

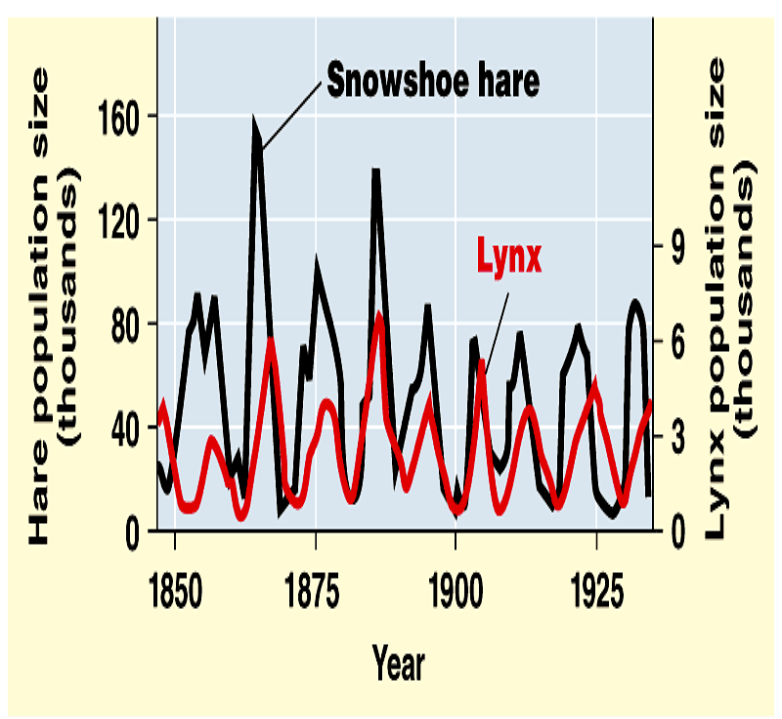


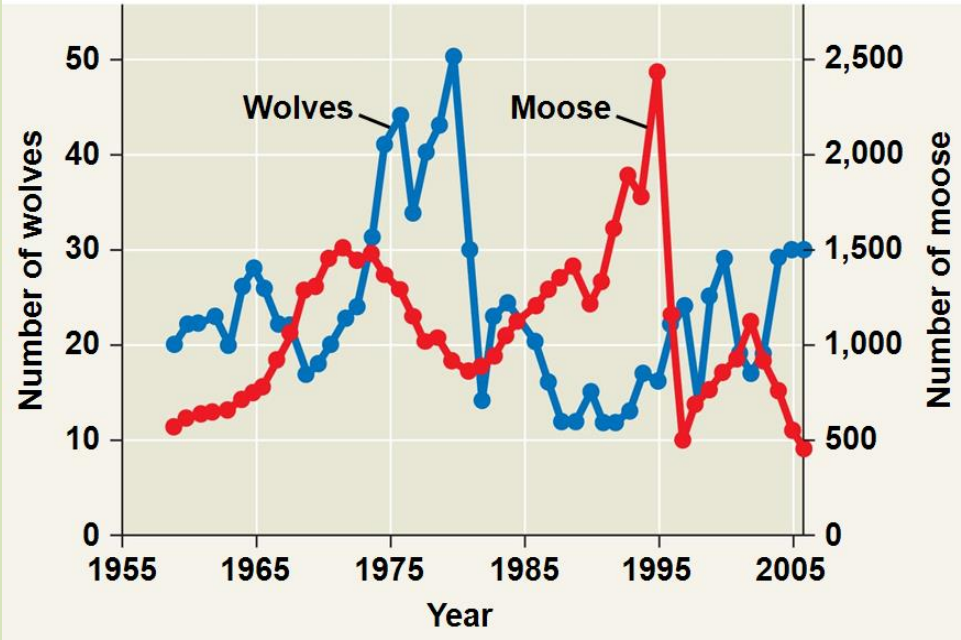
Strategies continued

- Semelparous reproduction
  - Expend their energy in a single, immense reproductive effort (grain crops, salmon, spider, r stategists)
- Iteroparous reproduction
  - Exhibit repeated reproductive cycles throughout their lifetimes (perennial plants, k strategists)

Predator – prey interactions

- Population cycles- food shortage, predation and sunspots

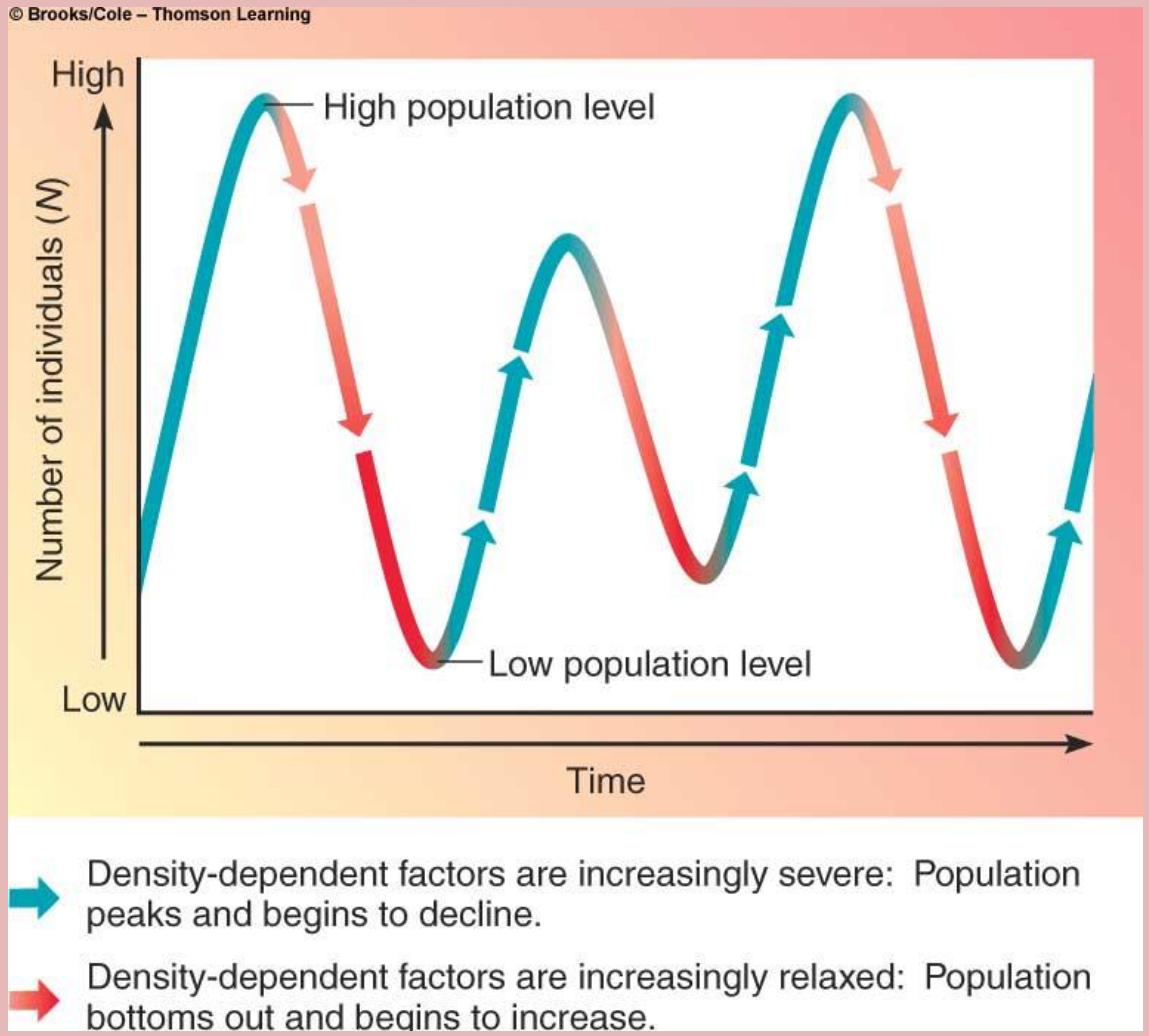




2005-2006

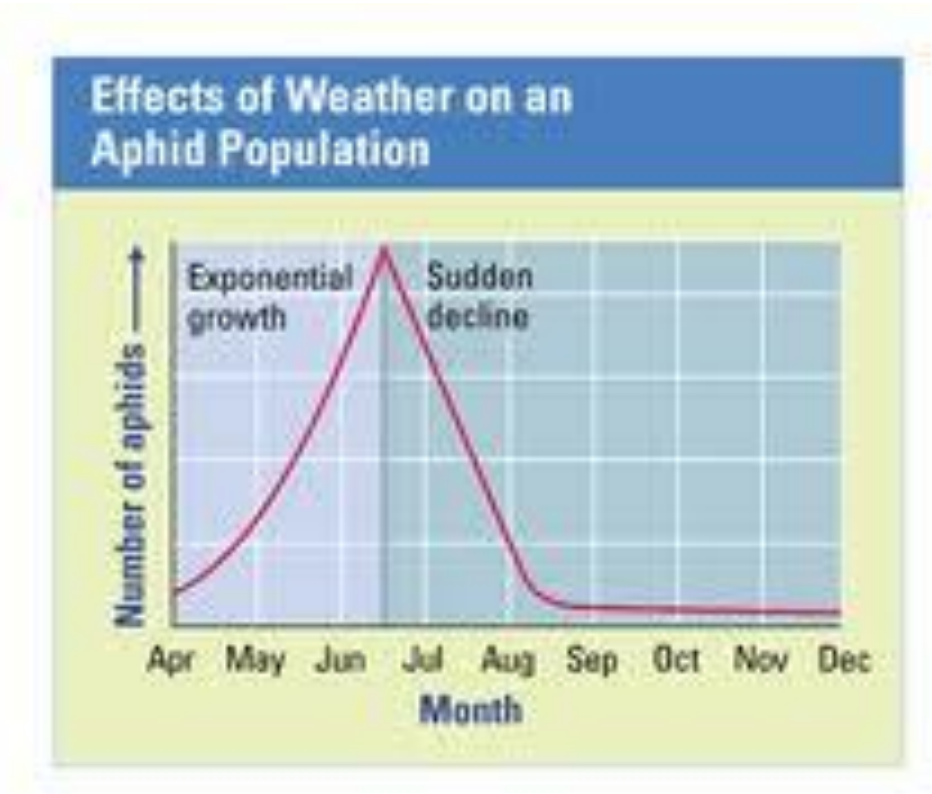
Density-dependent factors and negative feedback

- Regulate population growth by affecting a large proportion of the population as population rises
- Examples include predation, disease, and competition



Density-independent factors

- Limit population growth but are not influenced by changes in population density
- Examples include hurricanes and blizzards



Chapter 54

Community Ecology

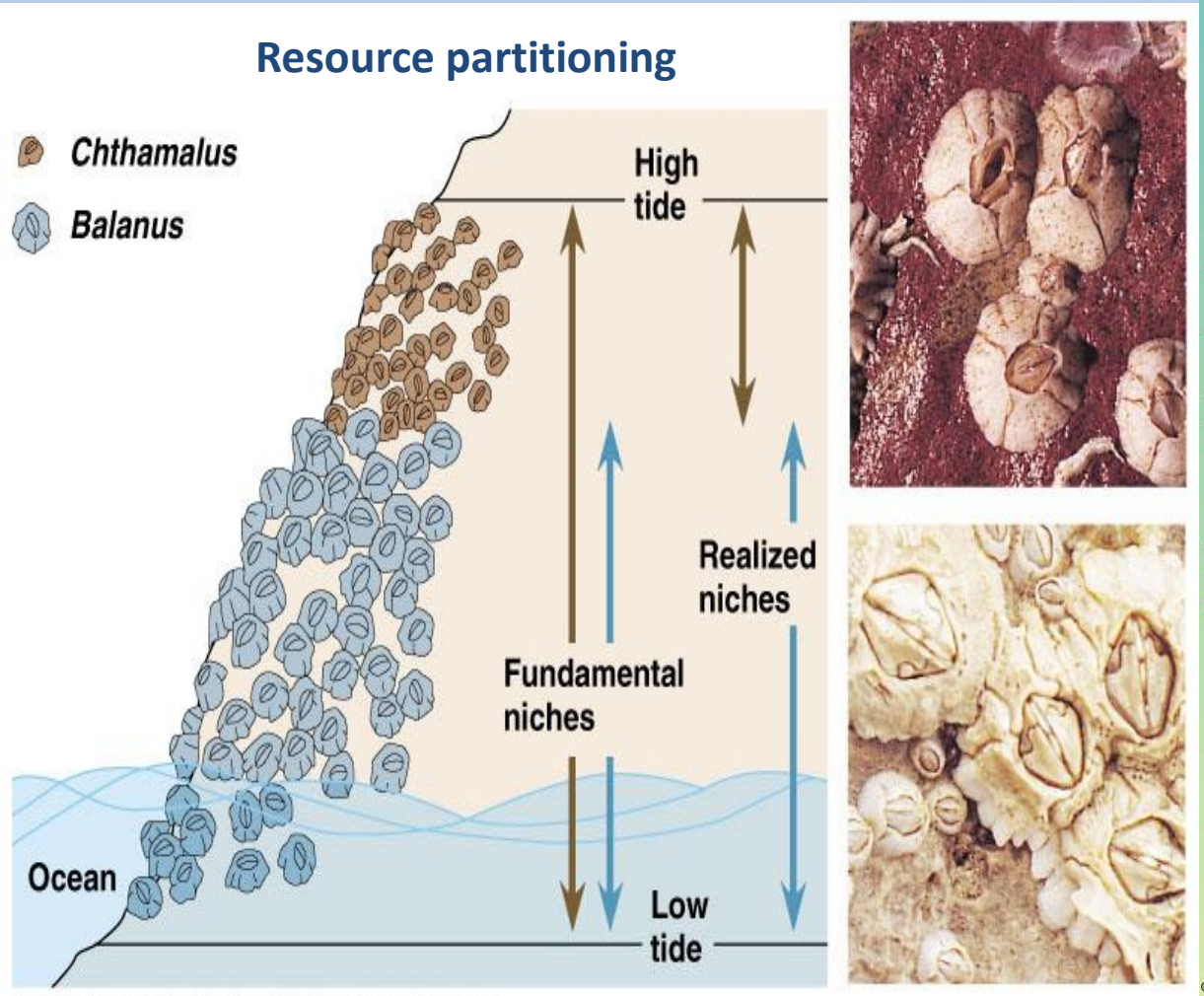
2005-2006

Inter-species interactions

- Symbiotic interactions
  - competition (-/-)
    - compete for limited resource
    - 2 species cannot coexist in a community if their niches are identical
  - predation / parasitism (-/+)
  - mutualism(+/+)
    - lichens (algae & fungus)
  - commensalism (+/0)
    - barnacles attached to whale

Niche

- An organism's niche is its ecological role (2 species can not have same niche) habitat = address, niche = job
- Competitive Exclusion



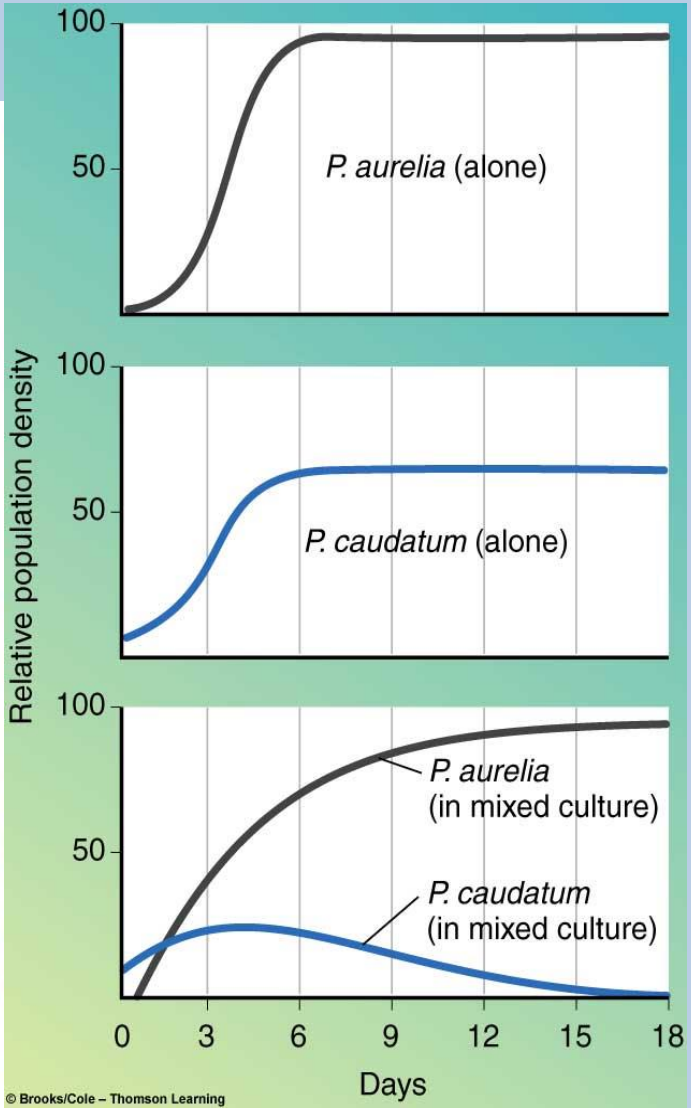
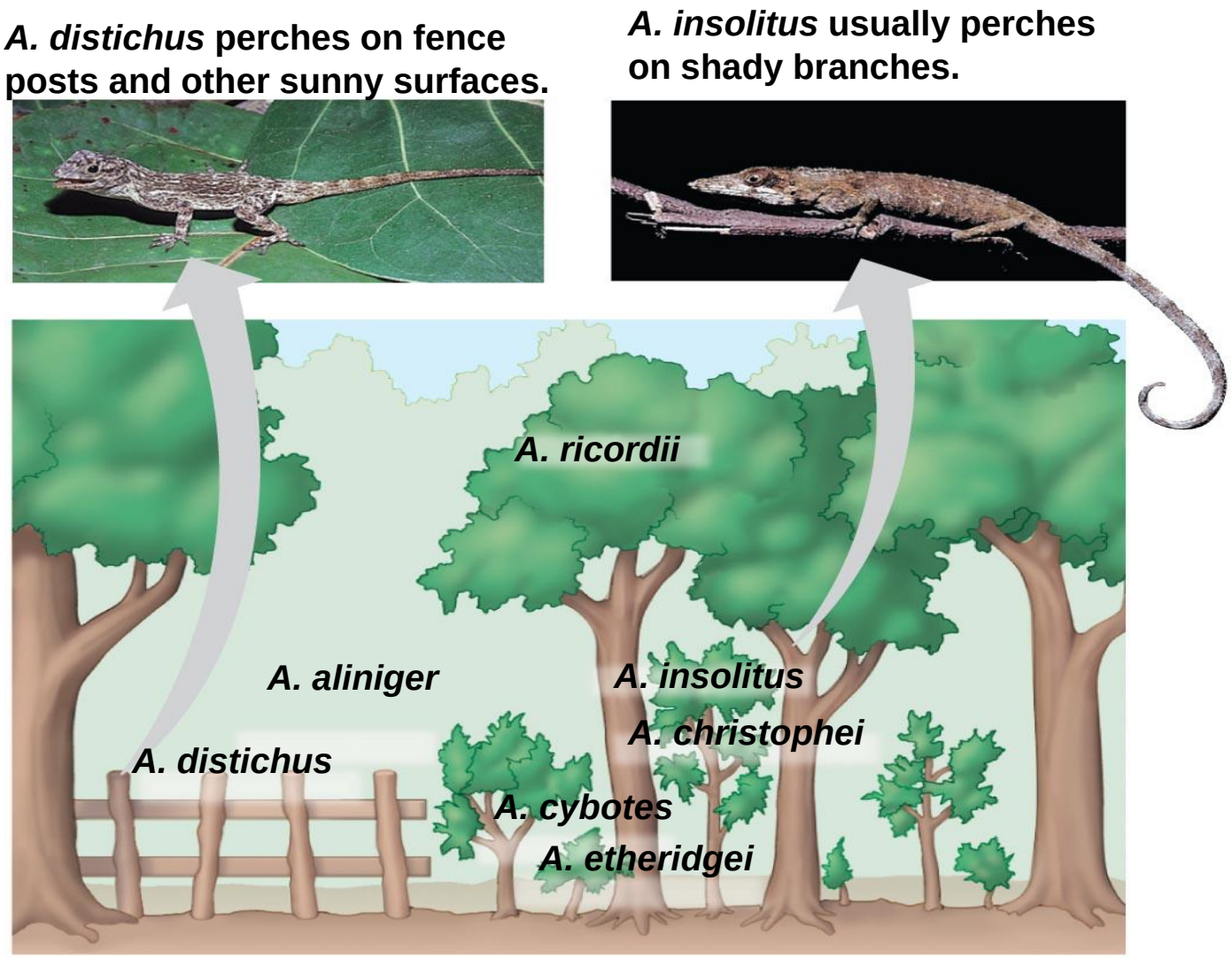


Fig. 54-2

Resource partitioning is differentiation of ecological niches, enabling similar species to coexist in a community



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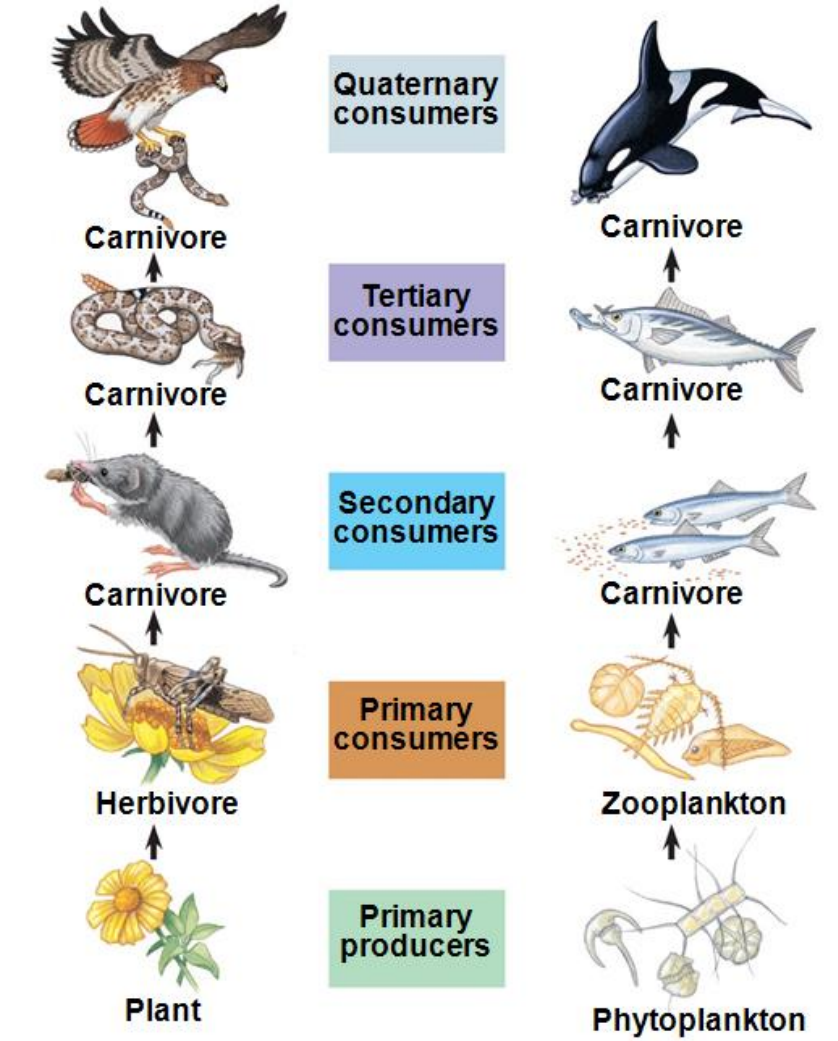
Energy Dynamics



A terrestrial food chain

A marine food chain

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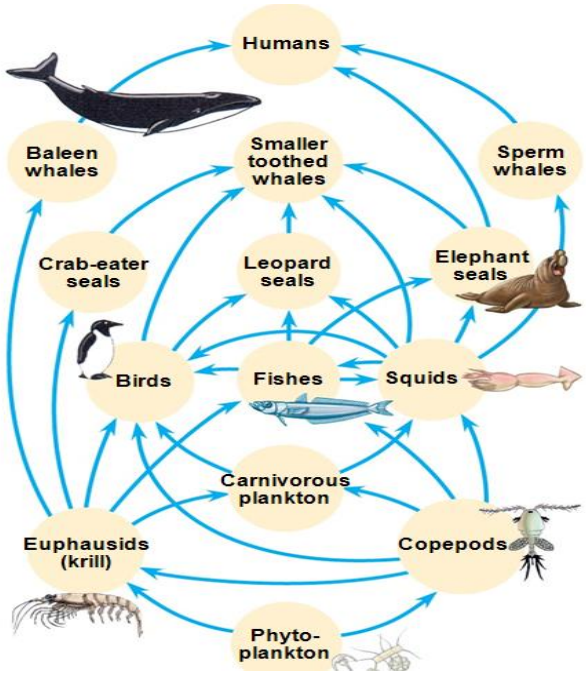

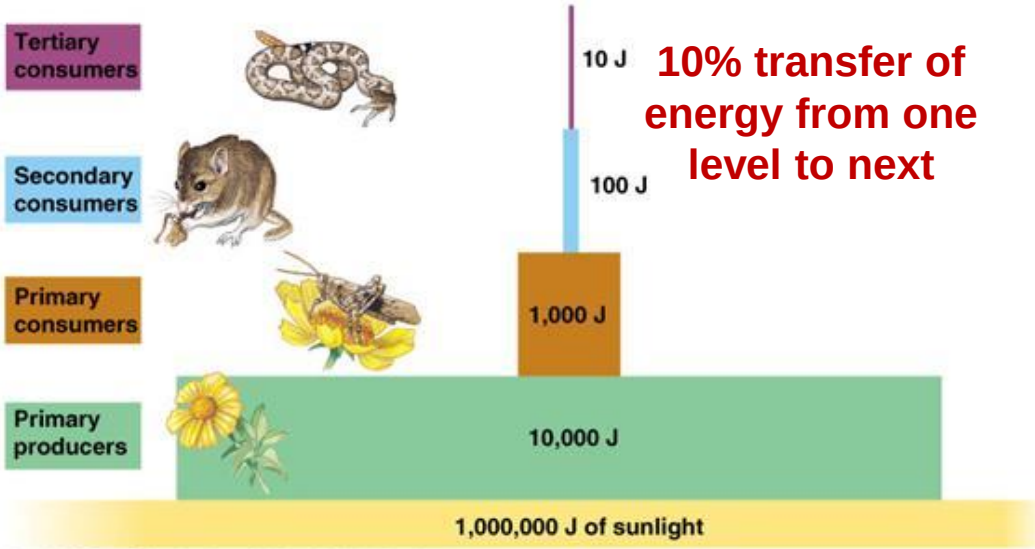

10% transfer of energy from one level to next

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Predation drives evolution

- Predators adaptations
  - locate & subdue prey
- Prey adaptations
  - elude & defend

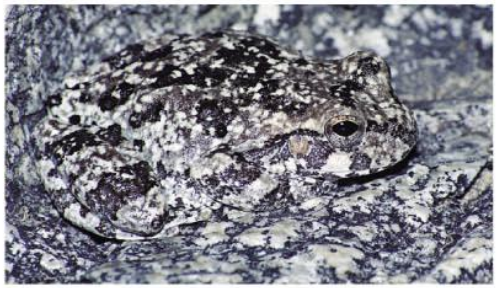
horns, speed, coloration

spines, thorns, toxins

Fig. 54-5

(a) Cryptic coloration

Canyon tree frog



(b) Aposematic coloration

Poison dart frog

-Behavioral defenses include hiding, fleeing, forming herds or schools, self-defense, and alarm calls

-Animals also have morphological and physiological defense adaptations

-Cryptic coloration, or camouflage, makes prey difficult to spot

(c) Batesian mimicry: A harmless species mimics a harmful one.

Hawkmoth larva

Green parrot snake

(d) Müllerian mimicry: Two unpalatable species mimic each other.

Cuckoo bee

Yellow jacket

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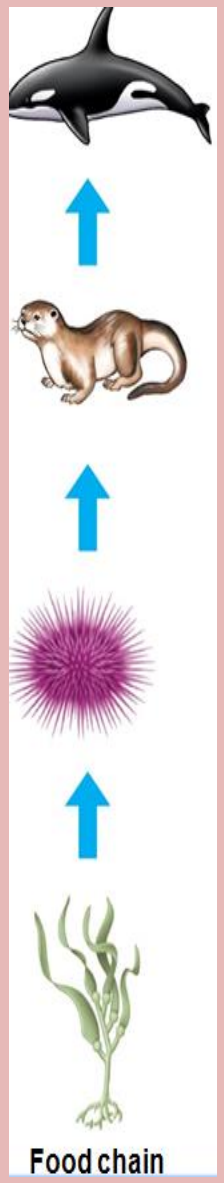
Species with a Large Impact on Community Structure and Dynamics

Dominant Species

- Most abundant or have the highest biomass (total mass of all individuals in a pop.)
- Exert control over the occurrence and distribution of other species
- Hypothesis suggests they are most competitive in exploiting resources or most successful at avoiding predators
- **Invasive species**, typically introduced to a new environment by humans, often lack predators or disease

Keystone Species

- **Keystone species** exert strong control on a community by their ecological roles, or niches
- not necessarily abundant in a community
- Removal Experiments
- Sea otters as keystone predators in North Pacific



Foundation Species (Ecosystem "Engineers")

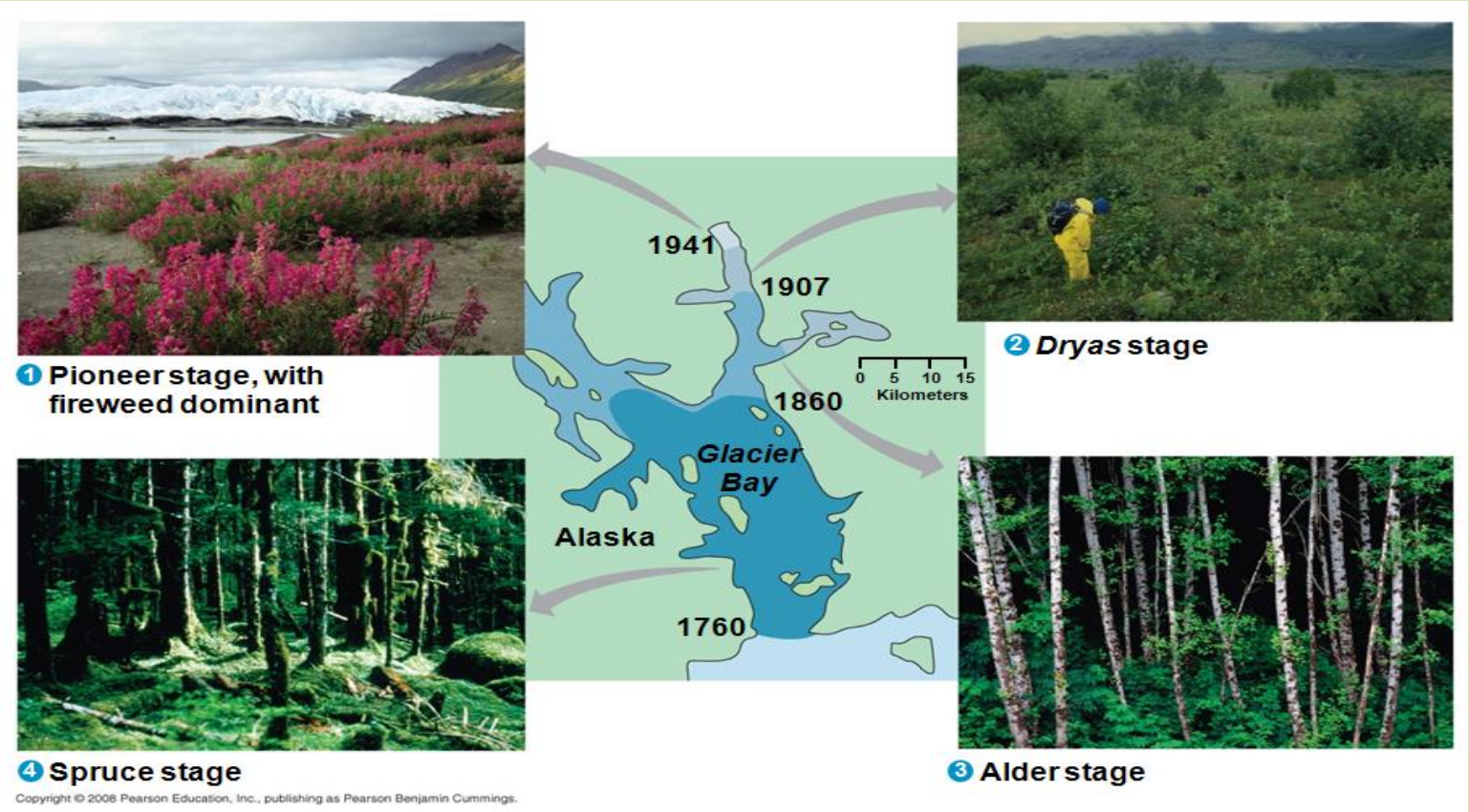
- Foundation species (ecosystem "engineers" or facilitators) exert influence not through trophic interactions but cause physical changes in the environment that affect community structure
- For example, beaver dams can transform landscapes on a very large scale

Ecological Succession

- **Ecological succession** is the sequence/transition of community and ecosystem changes after a disturbance, years to decades
- **Primary succession** occurs where no soil exists when succession begins
- **Secondary succession** begins in an area where soil remains after a disturbance

Pioneer Species- lichens and mosses

Climax Community



Disturbances

- Most communities are in a state of change due to disturbances
  - fire, weather, human activities, etc.
  - not all are negative

(a) Before a controlled burn. A prairie that has not burned for several years has a high proportion of detritus (dead grass).

(b) During the burn. The detritus serves as fuel for fires.

(c) After the burn. Approximately one month after the controlled burn, virtually all of the biomass in this prairie is living.

Disturbances

- Disturbances are often necessary for community development & survival
- Fires are part of a natural community cycle

(a) Soon after fire

(b) One year after fire

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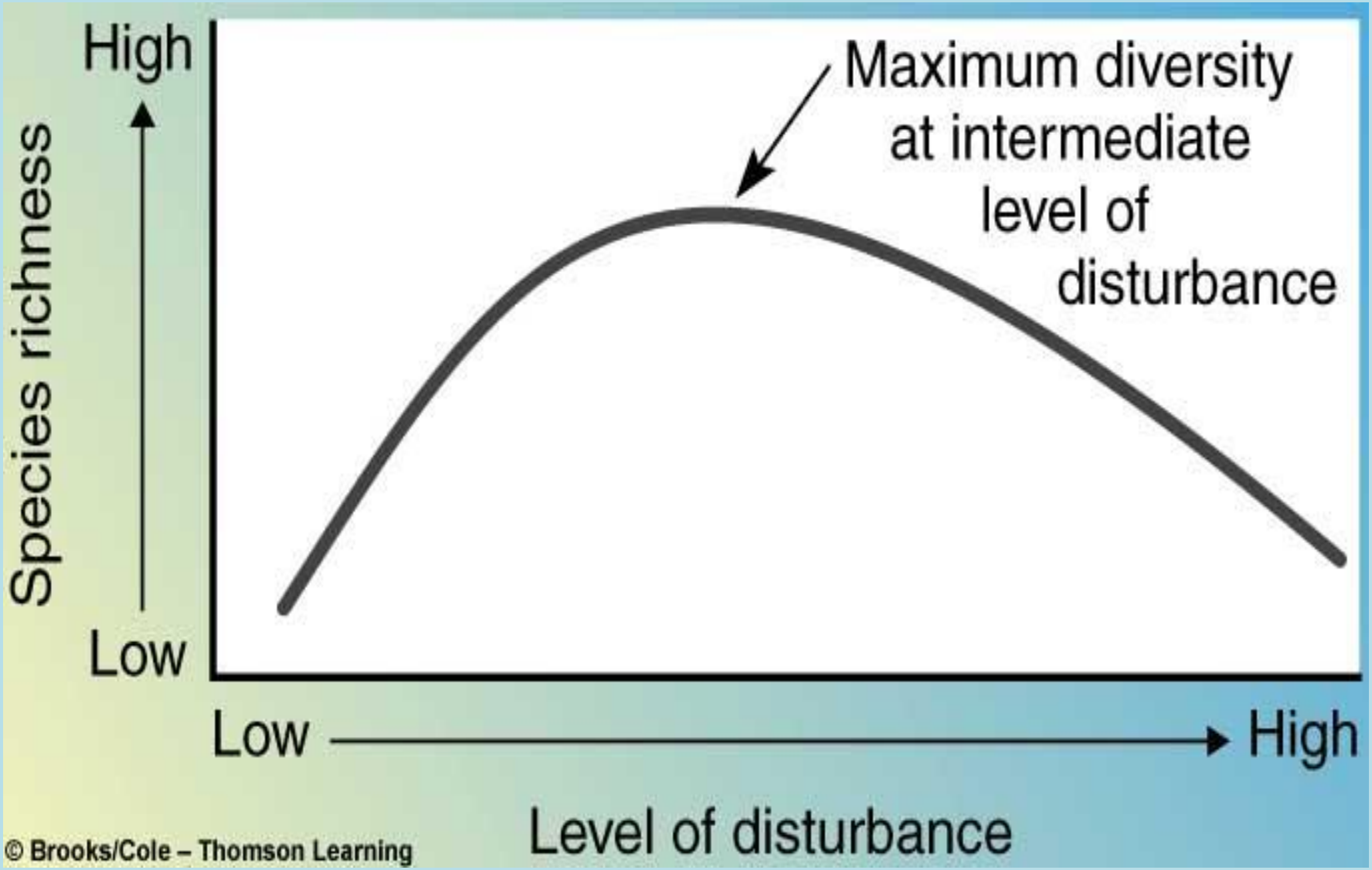
High
Low
Species richness
Maximum diversity at intermediate level of disturbance
Low
High
Level of disturbance
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Chapter 55

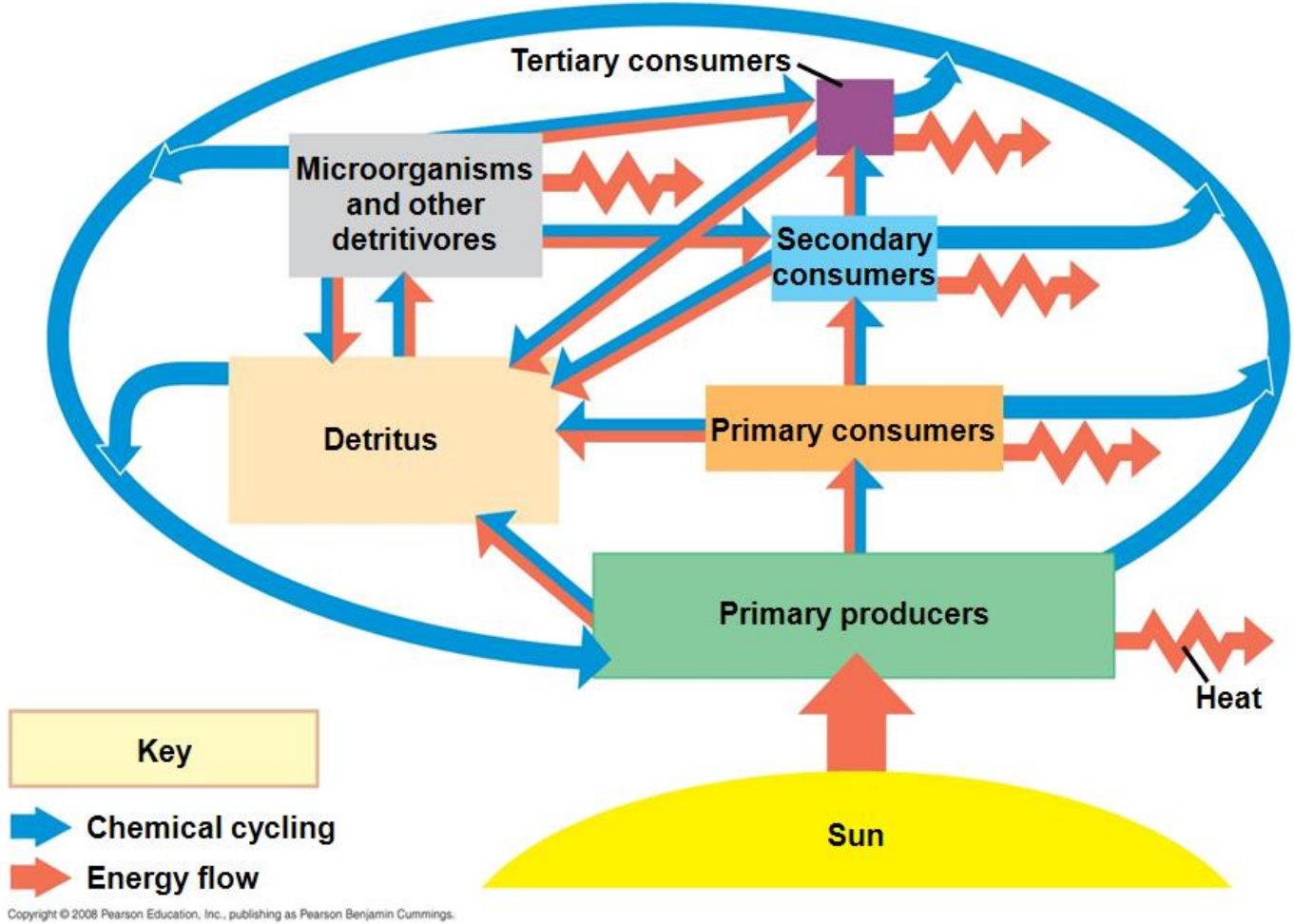
Ecosystem

- Community of organisms plus the abiotic factors that exist in a certain area

Energy transfer

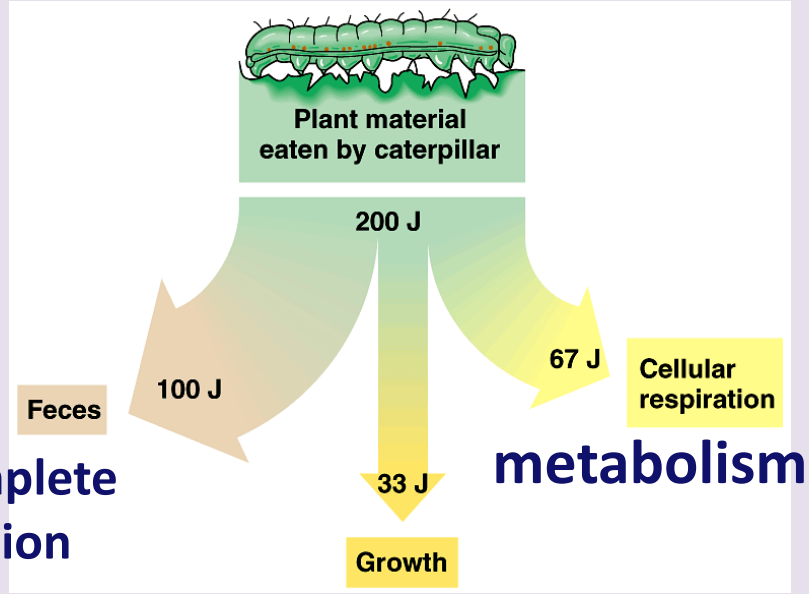
- Energy in
  - from the Sun then captured by autotrophs = producers (plants)
- Energy through
  - food chain

[transfer of energy from autotrophs to heterotrophs (consumers)]



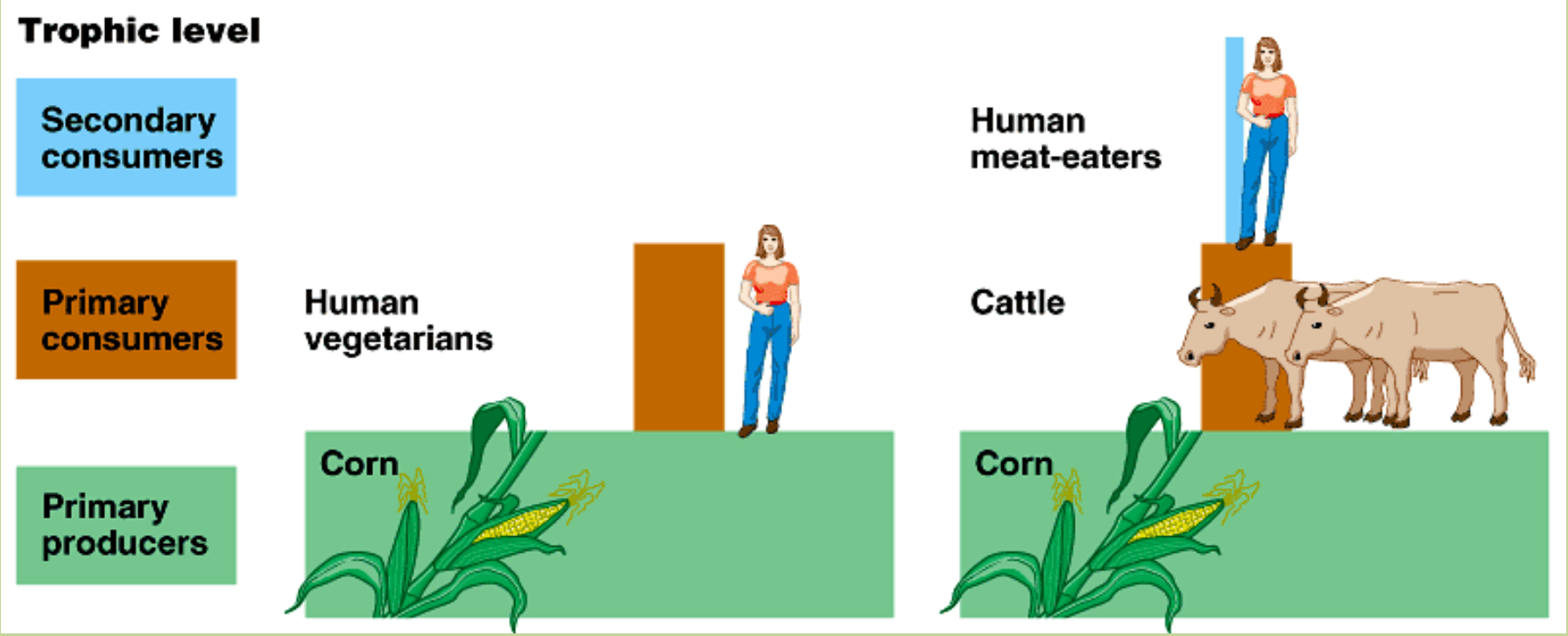
Energy inefficiency-Energy transfer between trophic levels is typically only 10% efficient

- Production efficiency: only fraction of E stored in food
- Energy used in respiration is lost as **heat**
- Energy flows (not cycle!) within ecosystems



Implications

- Dynamics of energy through ecosystems have important implications for human populations



Primary Production

- **Primary production** = amt. of light energy that is converted to chemical energy
- **Gross primary production (GPP)**: total primary production in an ecosystem
- **Net primary production (NPP)** = gross primary production minus the energy used by the primary producers for **respiration (R)**:

  NPP = GPP – R

- NPP = storage of chemical energy available to consumers in an ecosystem

Primary Production

- Primary production affected by:
  - Light availability (↑ depth, ↓ photosynthesis)
  - Nutrient availability (N, P in marine env.)
- Key factors controlling primary production:
  - Temperature & moisture

TABLE 53-1 Net Primary Productivities (NPP) for Selected Ecosystems*

Ecosystem	Average NPP (g dry matter/m^2/year)
Algal beds and reefs	2500
Tropical rain forest	2200
Swamp and marsh	2000
Estuaries	1500
Temperate evergreen forest	1300
Temperate deciduous forest	1200
Savanna	900
Boreal (northern) forest	800
Woodland and shrubland	700
Agricultural land	650
Temperate grassland	600
Upwelling zones in ocean	500
Lake and stream	250
Arctic and alpine tundra	140
Open ocean	125
Desert and semidesert scrub	90
Extreme desert (rock, sand, ice)	3

*Based on R.H. Whittaker, *Communities and Ecosystems*, 2nd ed., Macmillian, New York, 1975.

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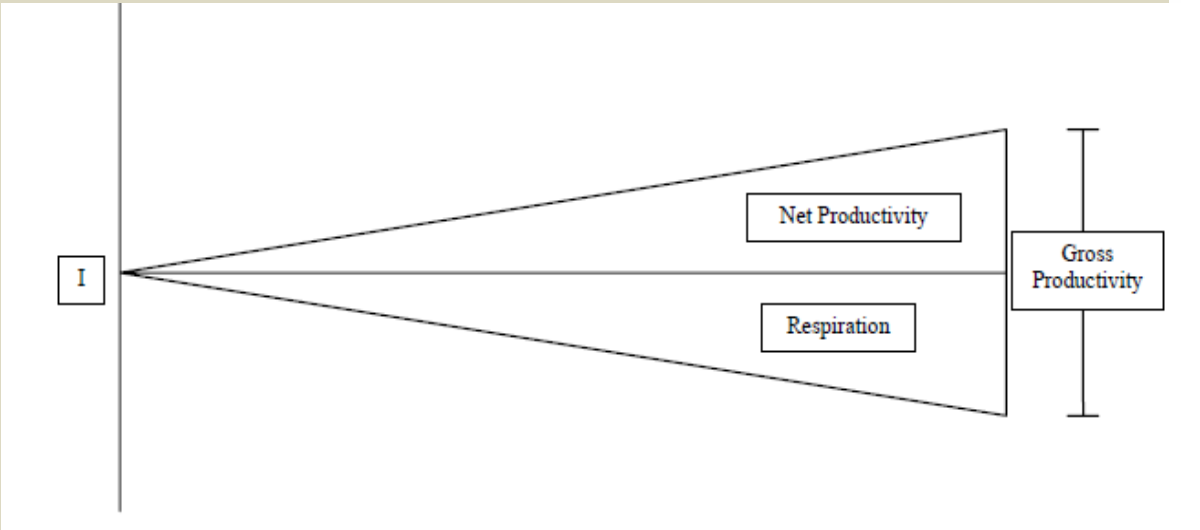
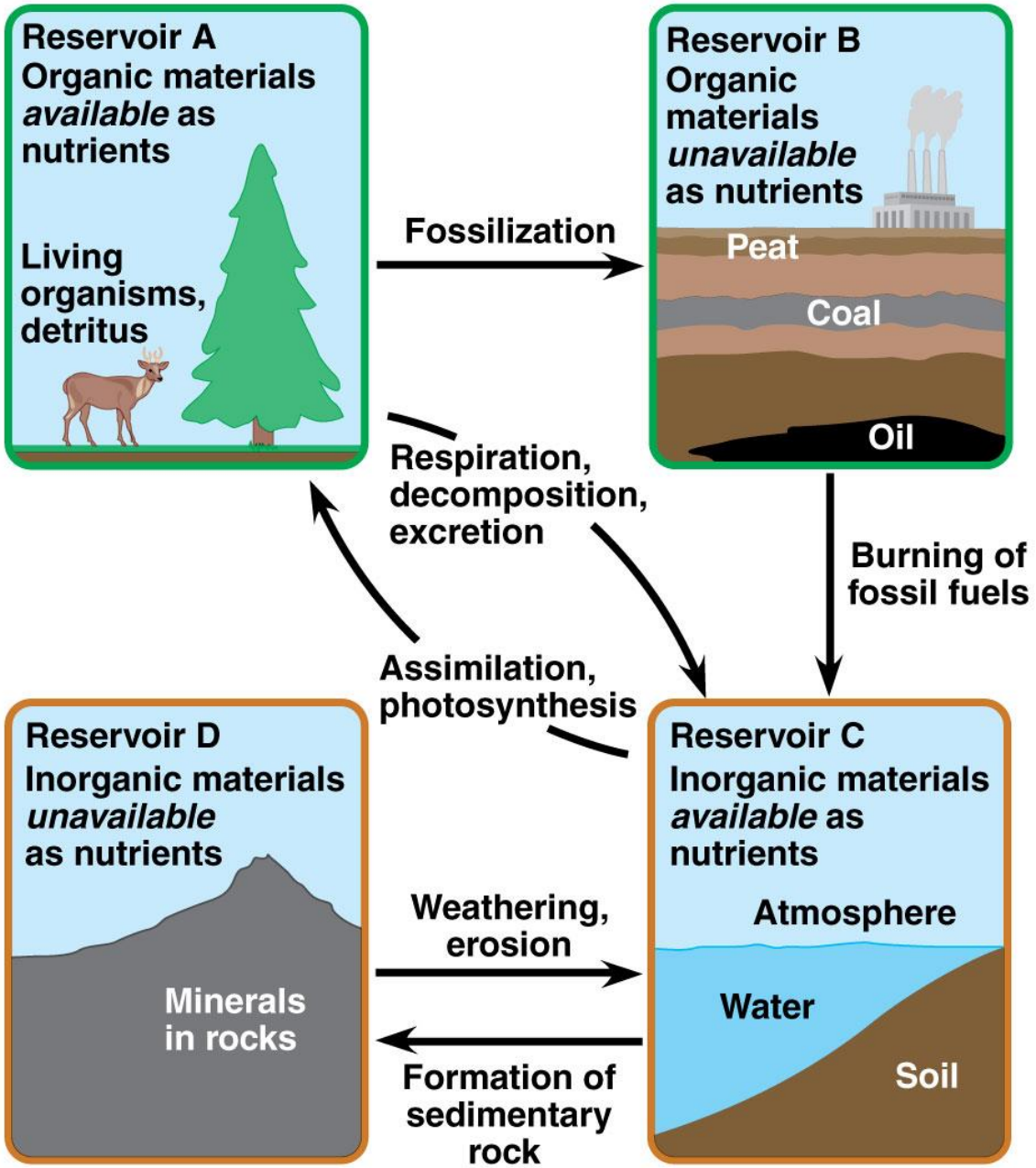
Measuring Primary Production

- Dissolved oxygen production or increase in biomass, or carbon dioxide uptake (oxygen probe)
- Initial/baseline comparison or light/dark bottle comparison
- Data analysis

- Light minus initial= net productivity
- Initial minus dark= respiration
- Light minus dark= gross productivity



Biogeochemical Cycles- Nutrient cycling



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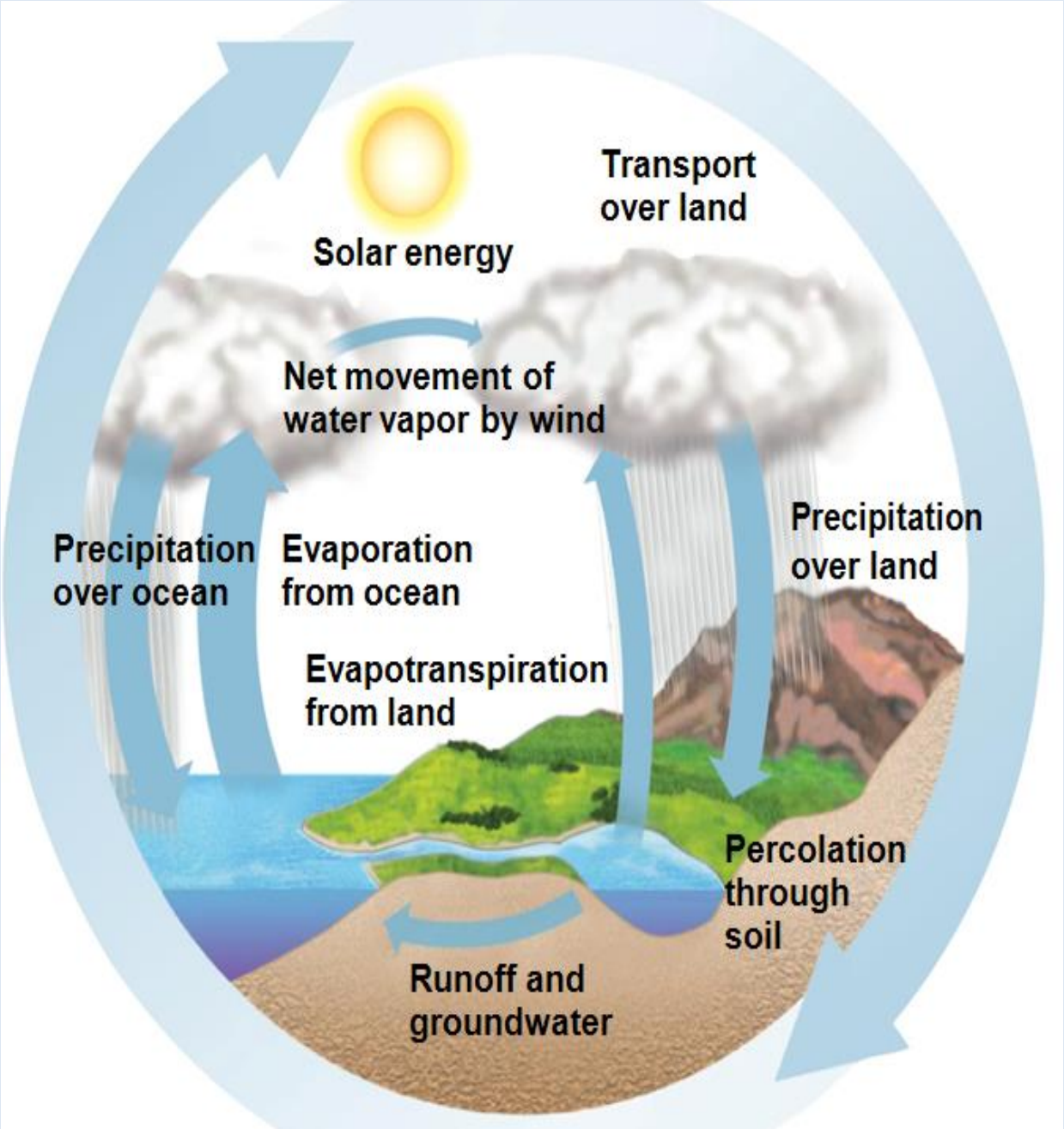
Water Cycle

abiotic reservoir:
- surface & atmospheric water

enter food chain:
- precipitation & plant uptake

recycle:
- transpiration

return to abiotic:
- evaporation & runoff



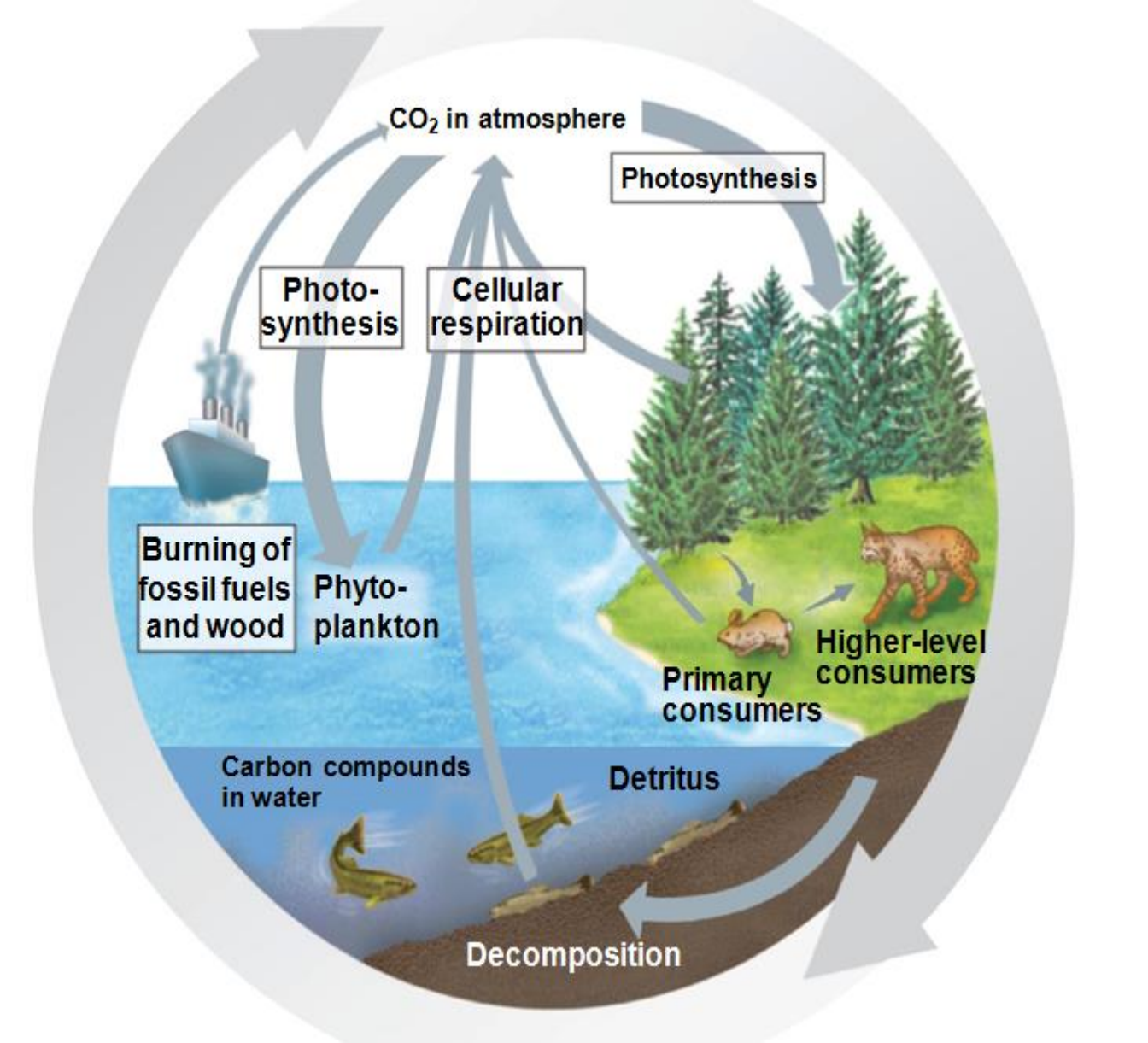
Carbon cycle

abiotic reservoir:
- CO_2 in atmosphere

enter food chain:
- photosynthesis = carbon fixation in Calvin cycle

recycle:
- decomposition

return to abiotic:
- respiration
- combustion



Nitrogen cycle

Nitrate:
NO_3^-, NO_2^-

Ammonium:
NH_4^+, NH_4^+

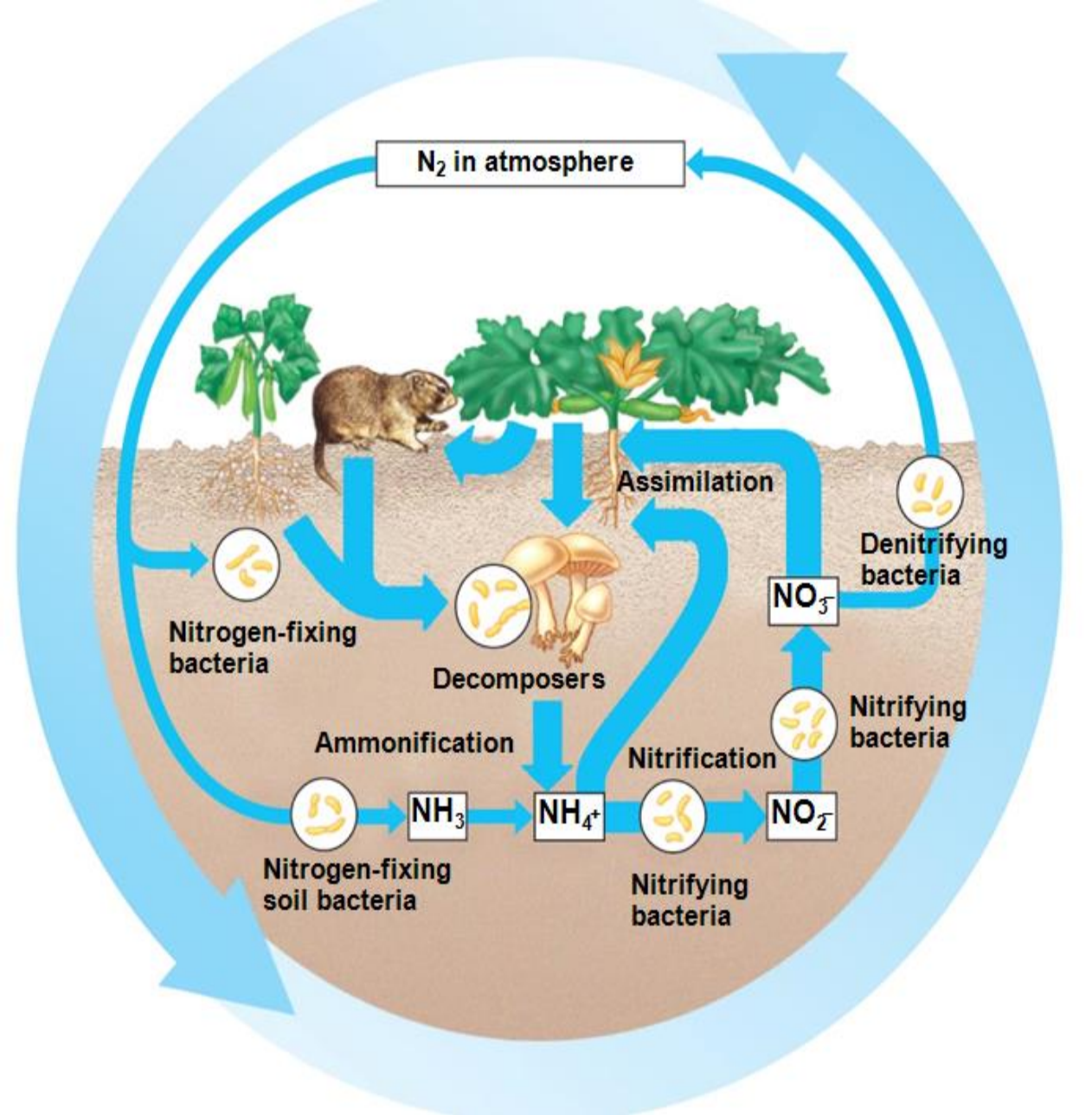
Nitrogen Gas:
N_2

abiotic reservoir:
- N in atmosphere

enter food chain:
- nitrogen fixation by soil & aquatic bacteria

recycle:
- decomposing & nitrifying bacteria

return to abiotic:
- denitrifying bacteria



Phosphorus cycle

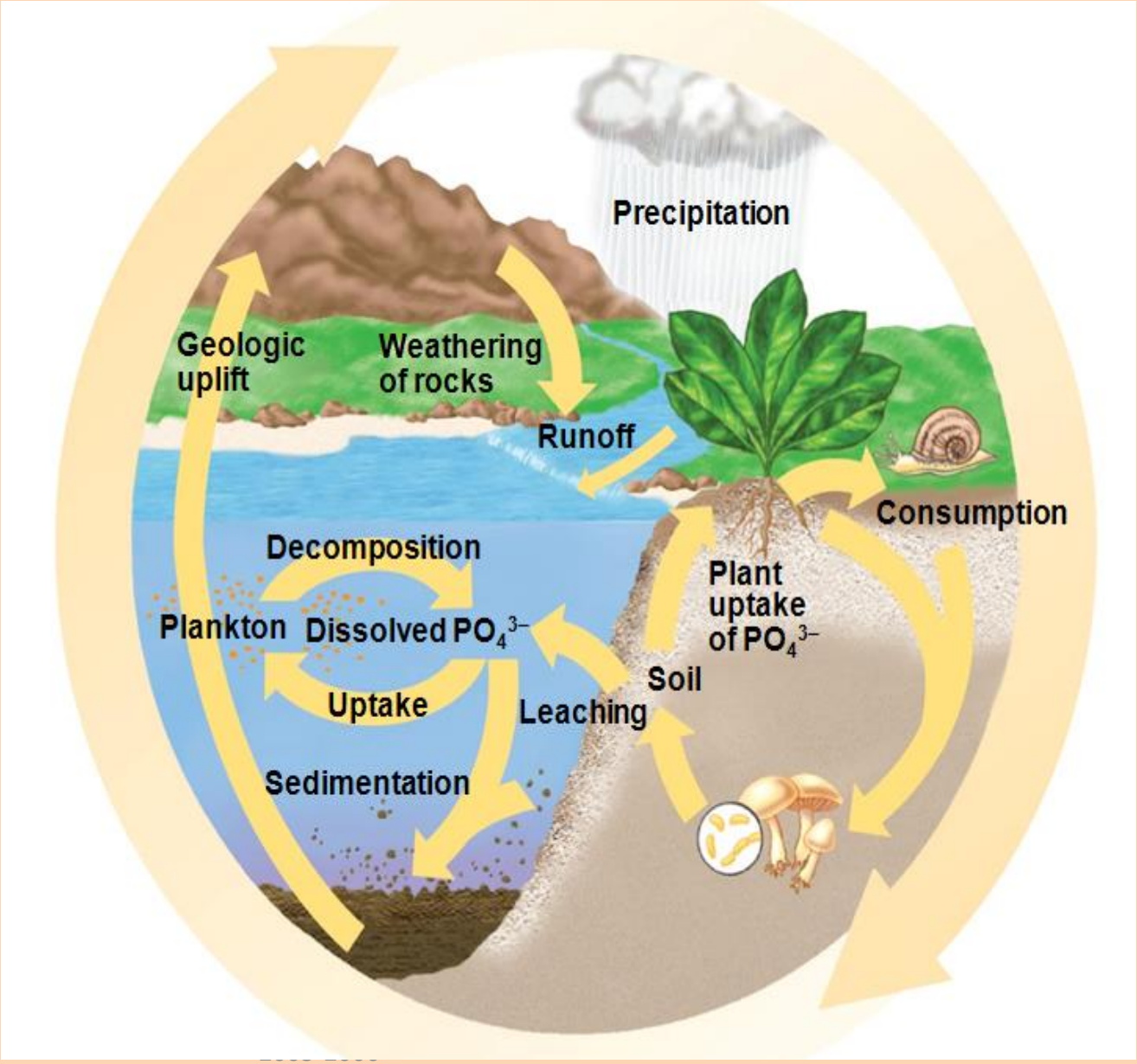
Phosphate: PO_4^{3-}

abiotic reservoir:
- rocks, minerals, soil

enter food chain:
- erosion releases soluble phosphate
- uptake by plants

recycle:
- decomposing bacteria & fungi

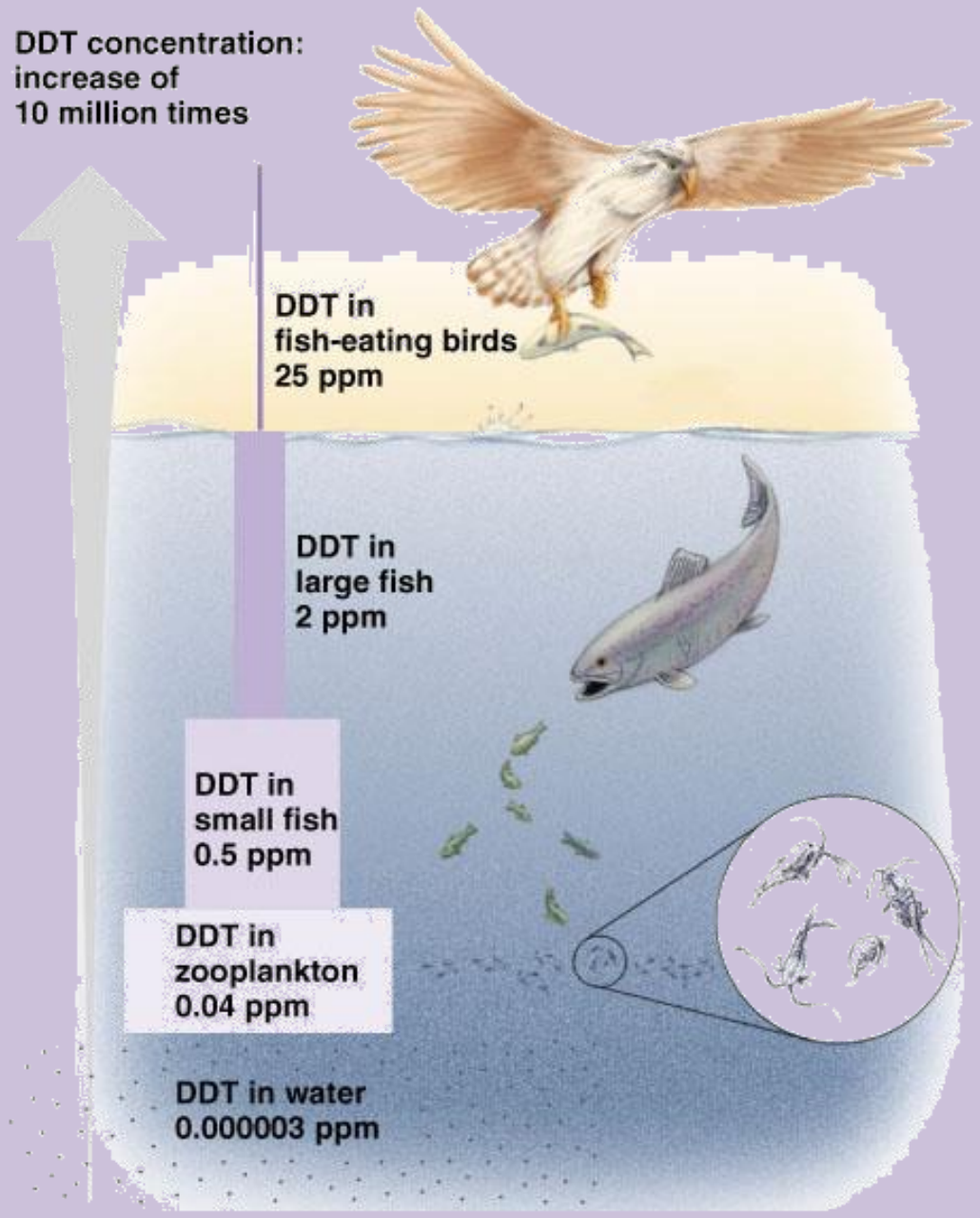
return to abiotic:
- loss to ocean sediment



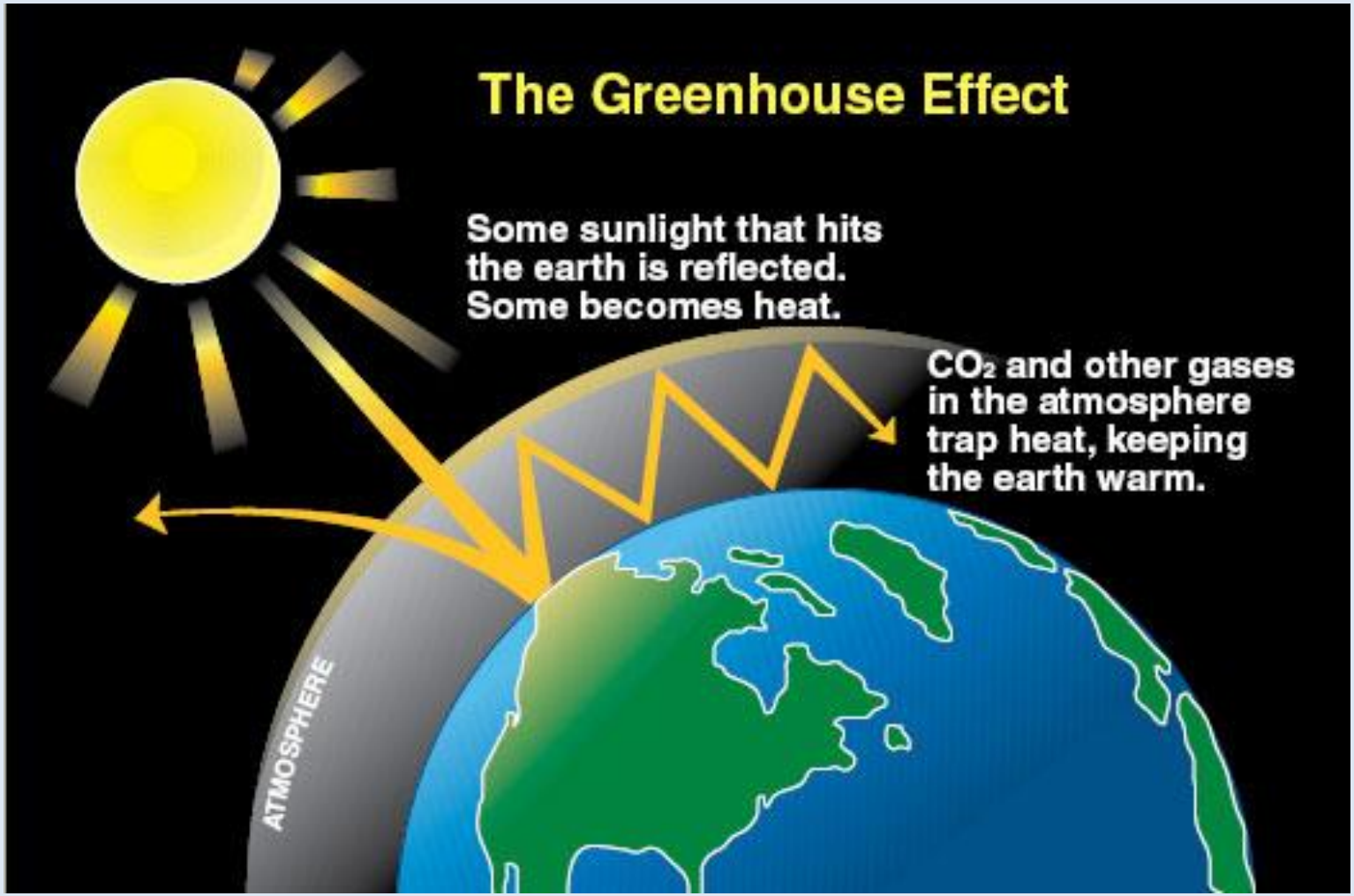
Biological Magnification

EX: DDT
Pesticide used to kill mosquitos;
Concentrated in eagles causing them to lay eggs with brittle shells;

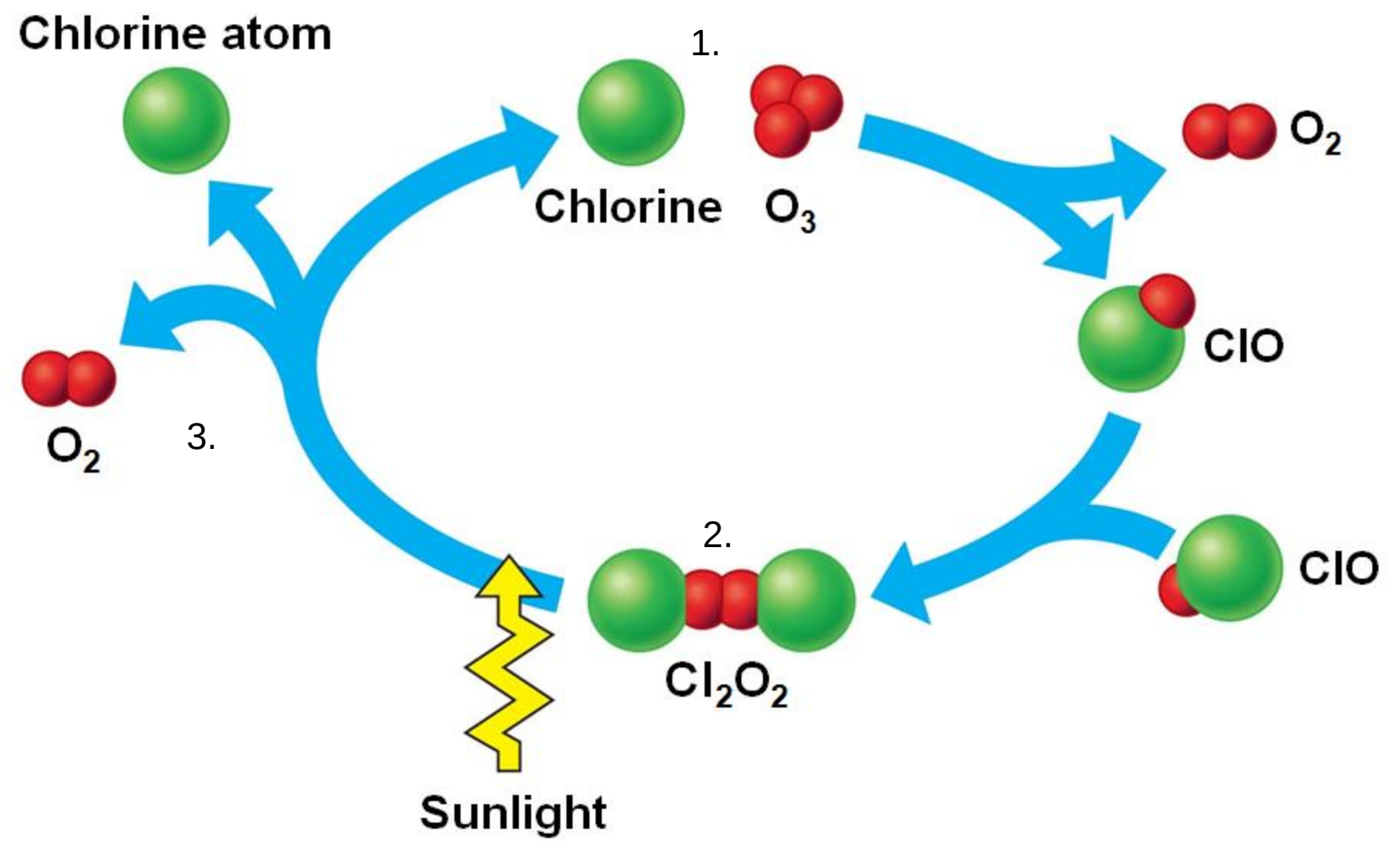
Banning DDT has brought bald eagle populations back



Greenhouse Effect



Decrease in Ozone



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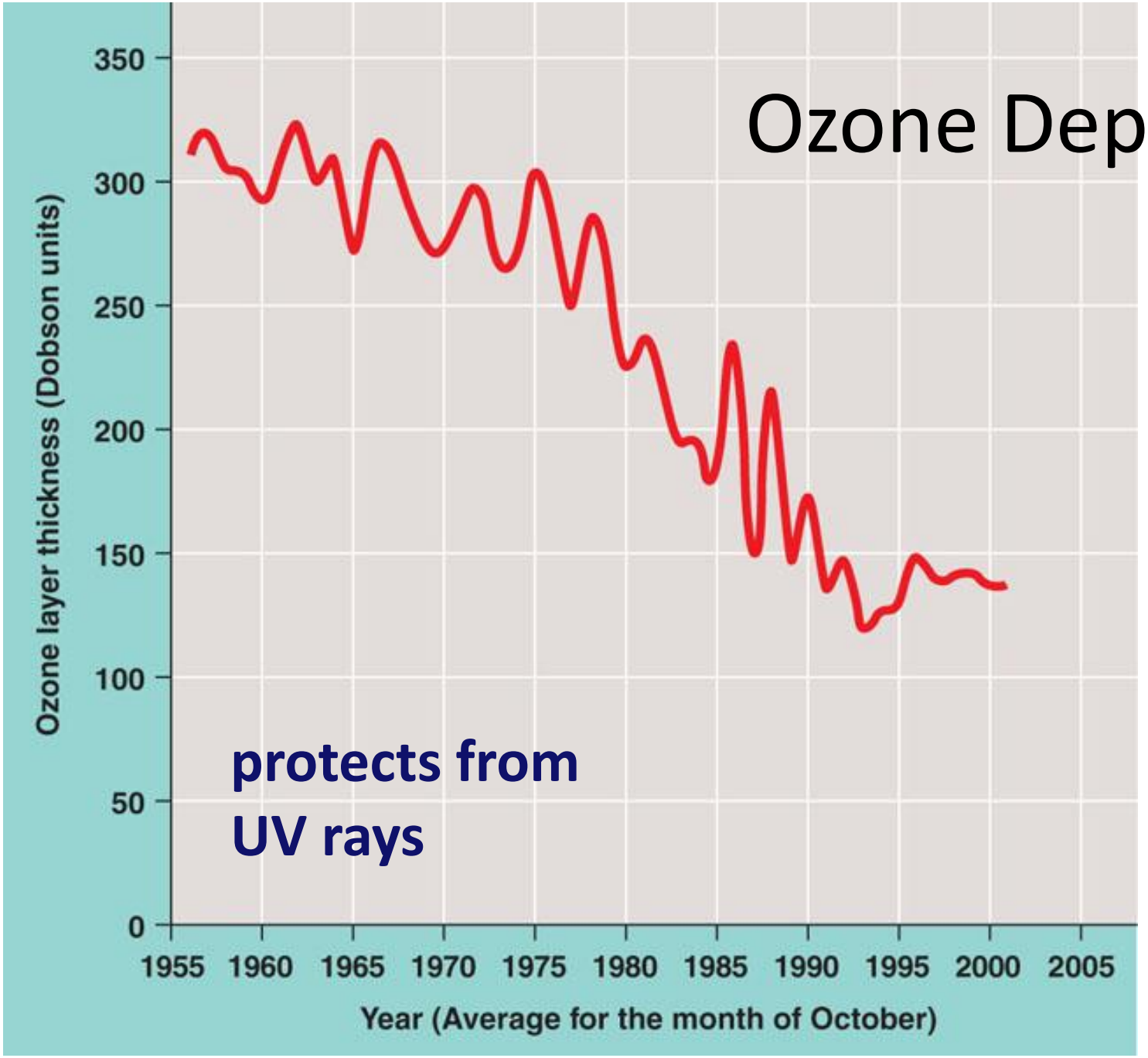
Ozone Depletion



protects from UV rays

Combustion of fossil fuels is the main cause of acid precipitation

10X = ten times **more acidic** than the pH 5.6 of "normal" rainwater.

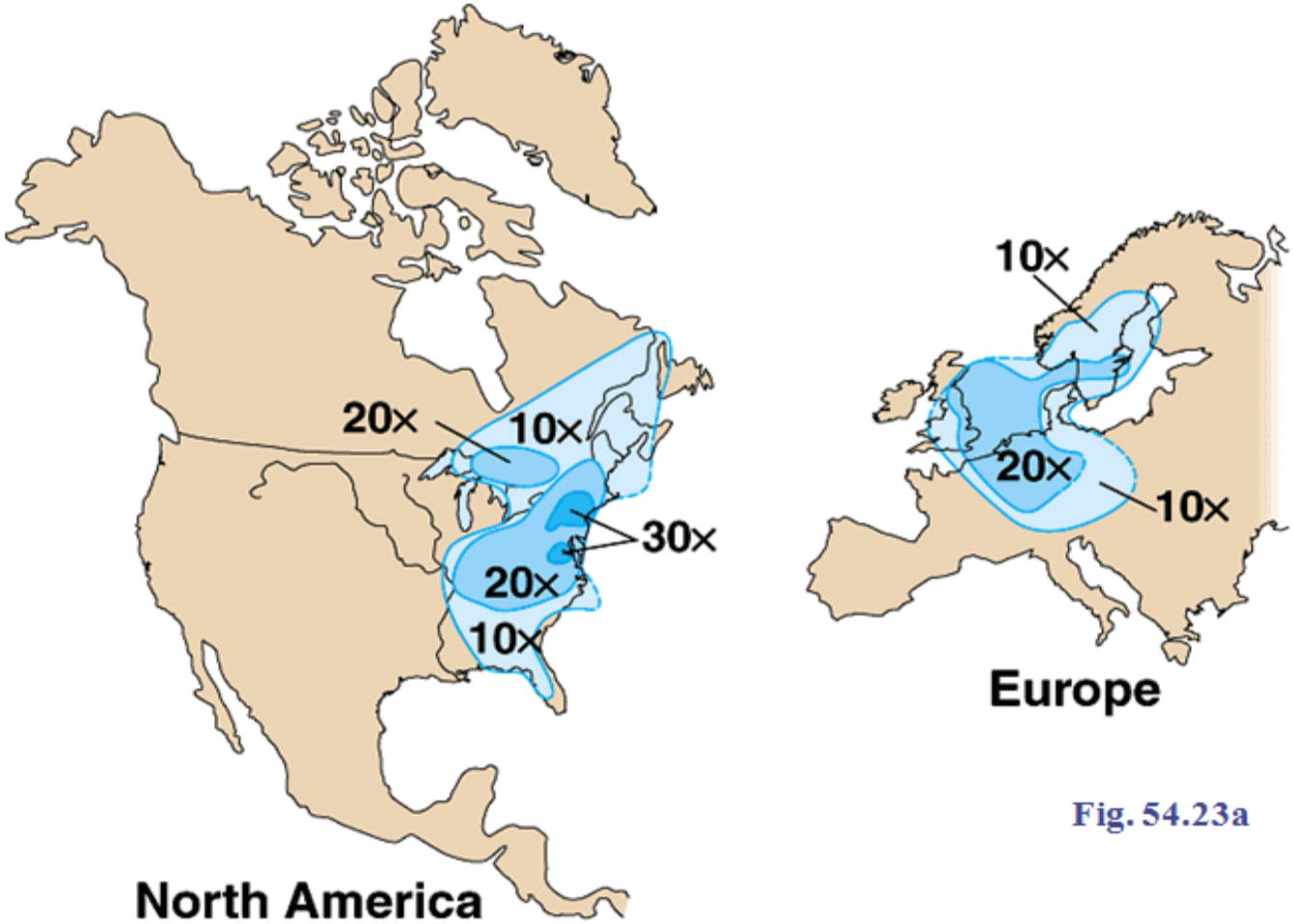


Fig. 54.23a

(a)

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Chapter 56: Conservation

2005-2006

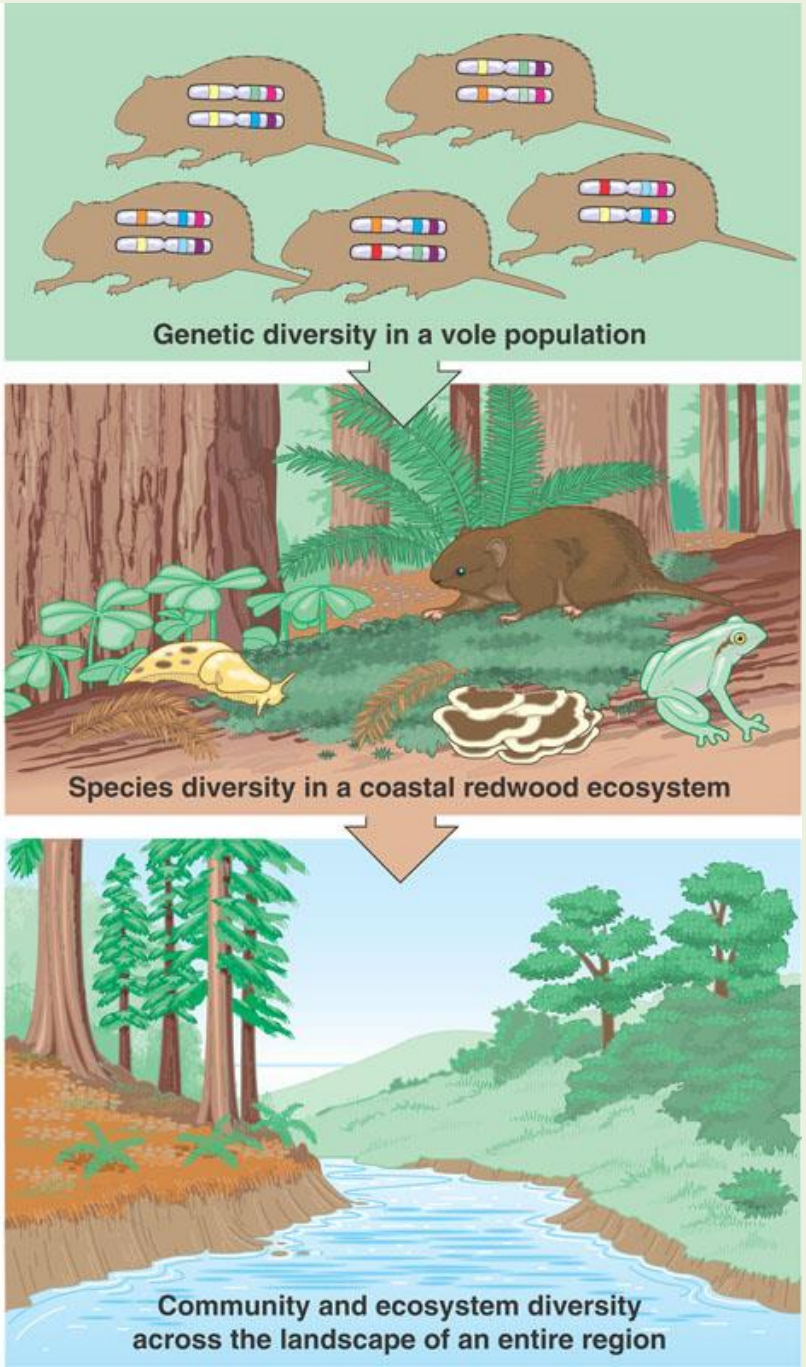
Barry Commoner's Laws of Ecology

- Everything is connected to everything else
- Everything must go somewhere
  - there is no such place as "away"
- Nature knows best
- There is no such thing as a free lunch

Laws of Unintended Consequences

Loss of Diversity

- 3 levels of biodiversity
  - ecosystem diversity
  - mix of species in community
  - genetic diversity within population
- All decreased by human activity
  - loss of genetic diversity
  - loss of biodiversity



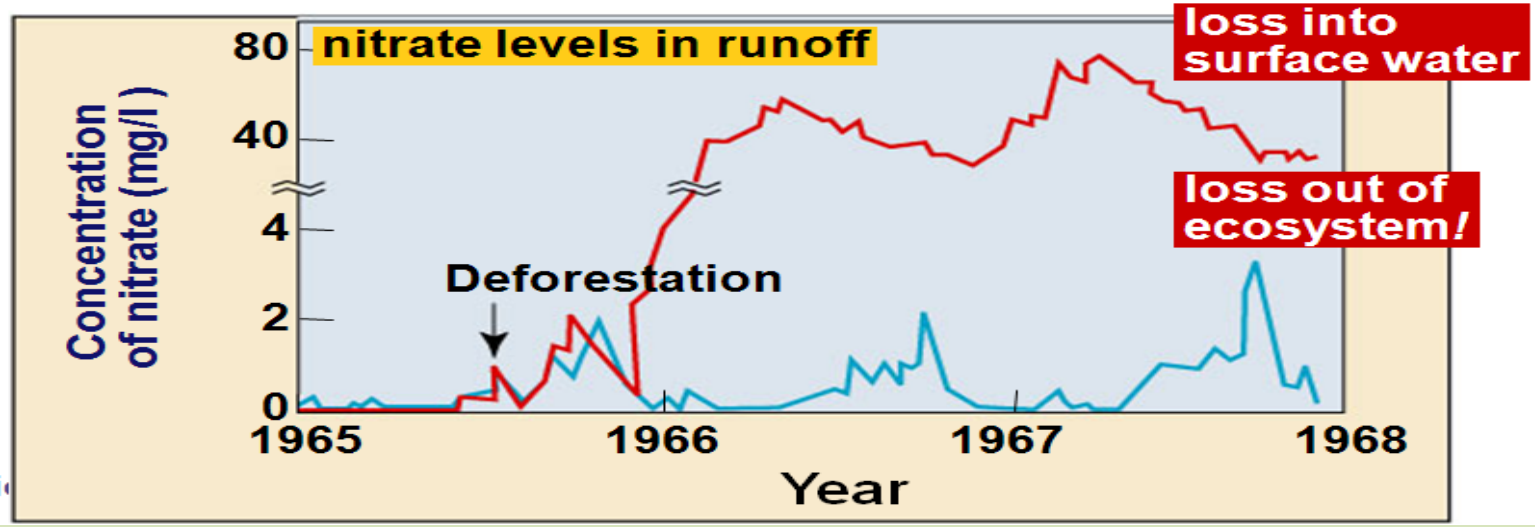
Deforestation / Habitat Loss

- Loss of habitat
- Loss of biodiversity
- Loss in photosynthesizers
- Breaks the water cycle

Effects of deforestation

40% increase in runoff
- loss of water

- 60x loss in nitrogen
- 10x loss in calcium



AP Bi

Fragmented Habitat

- Loss of habitat
- Loss of food resource for higher levels on food chain
- Loss of biodiversity
- Loss of stability

Introduced species

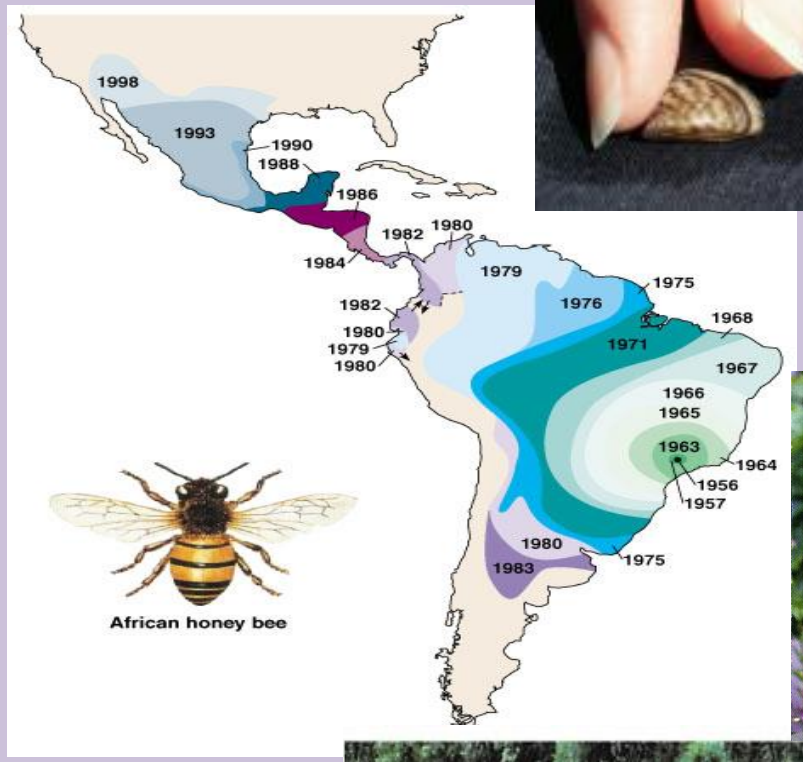
-transplanted populations grow exponentially in new area

-non-native species out-compete native species

-lack of competitors & predators, reduce diversity

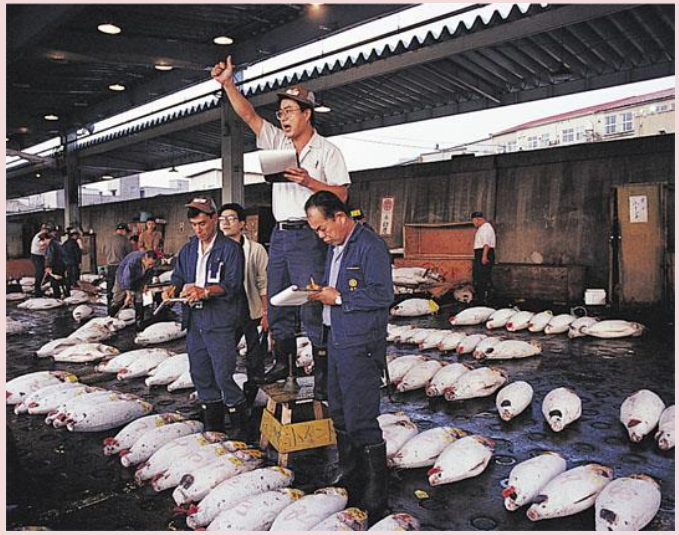
- Loss of nesting sites and food

- examples
  - African honeybee
  - gypsy moth
  - zebra mussel
  - purple loosestrife



gypsy moth

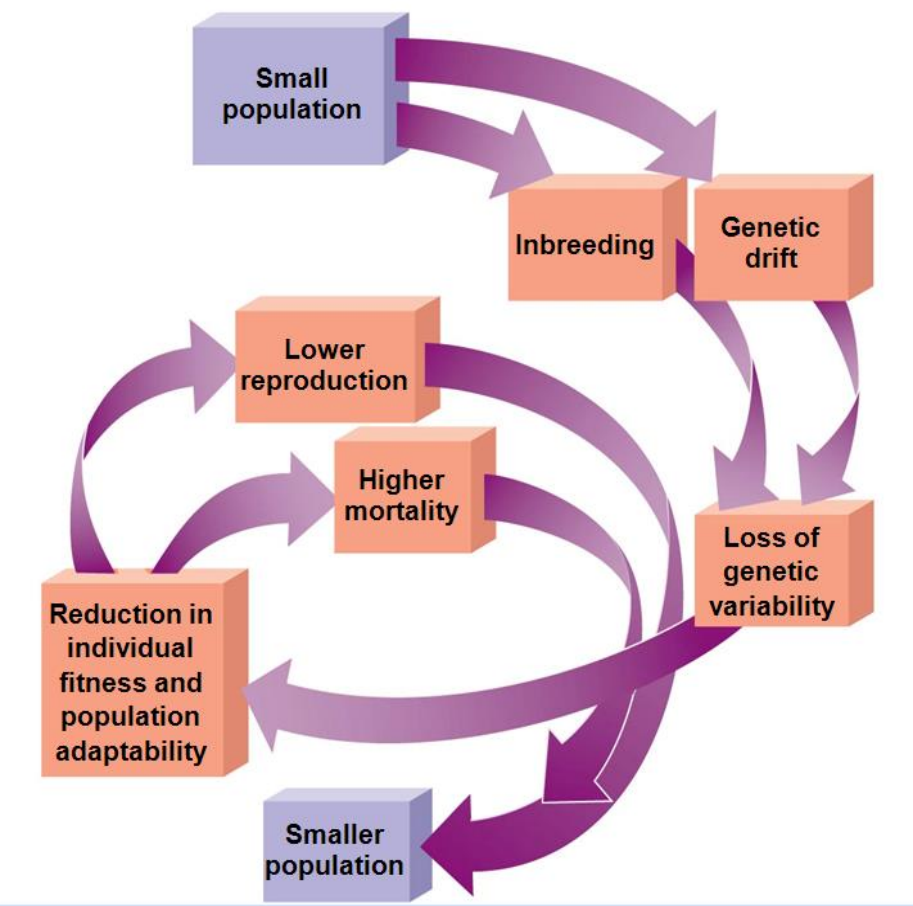
Overexploitation



- Loss of food resource for higher levels on food chain
- Loss of biodiversity
- Loss of keystone species?
- Loss of stability

Population Conservation

Small Population Approach



Declining Population Approach

Red-cockaded woodpecker

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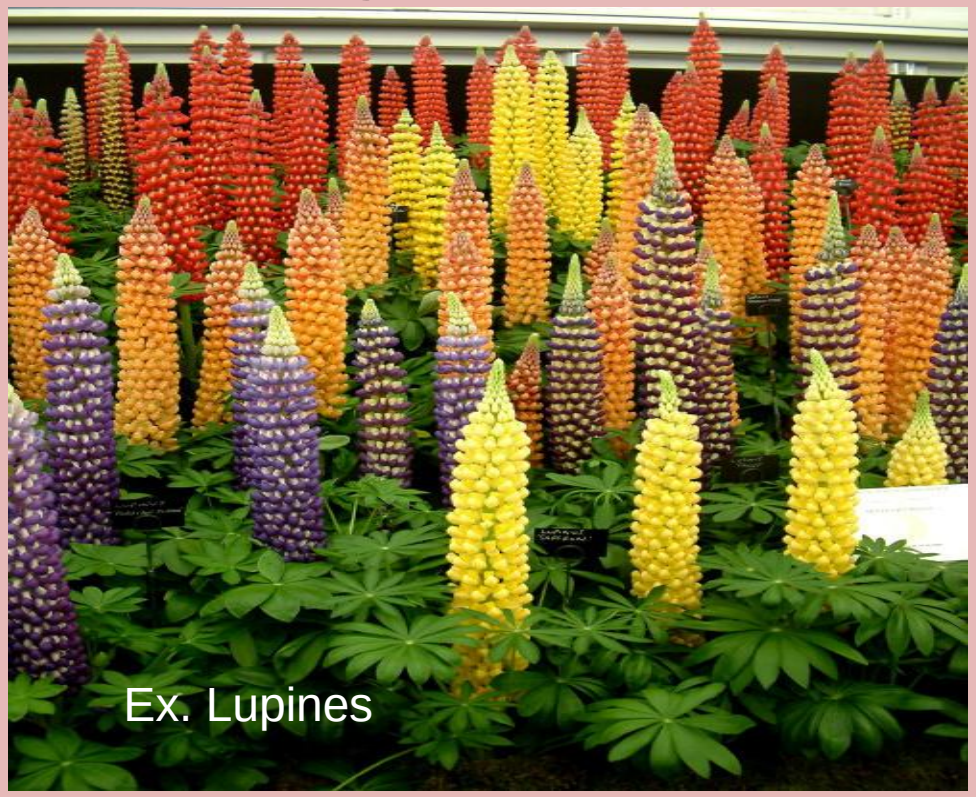
Restoration Ecology

Bioremediation- use of organisms to detoxify polluted areas

Geobacter metallireducens

Biological Augmentation- use organisms to add essential materials to degraded area



Think Globally, Act Locally