Ecosystems

community of different species interacting with one another AND with their nonliving environment of matter & energy

Components of Ecosystem

1. Biotic - living (plants, animals, microorganisms)
2. Abiotic – non-living (water, air, nutrients, land)
   - **NON-LIVING COMPONENTS**
   - Physical and chemical factors that influence living organisms
   - each population has a range of tolerance to variations in its physical & chemical environment

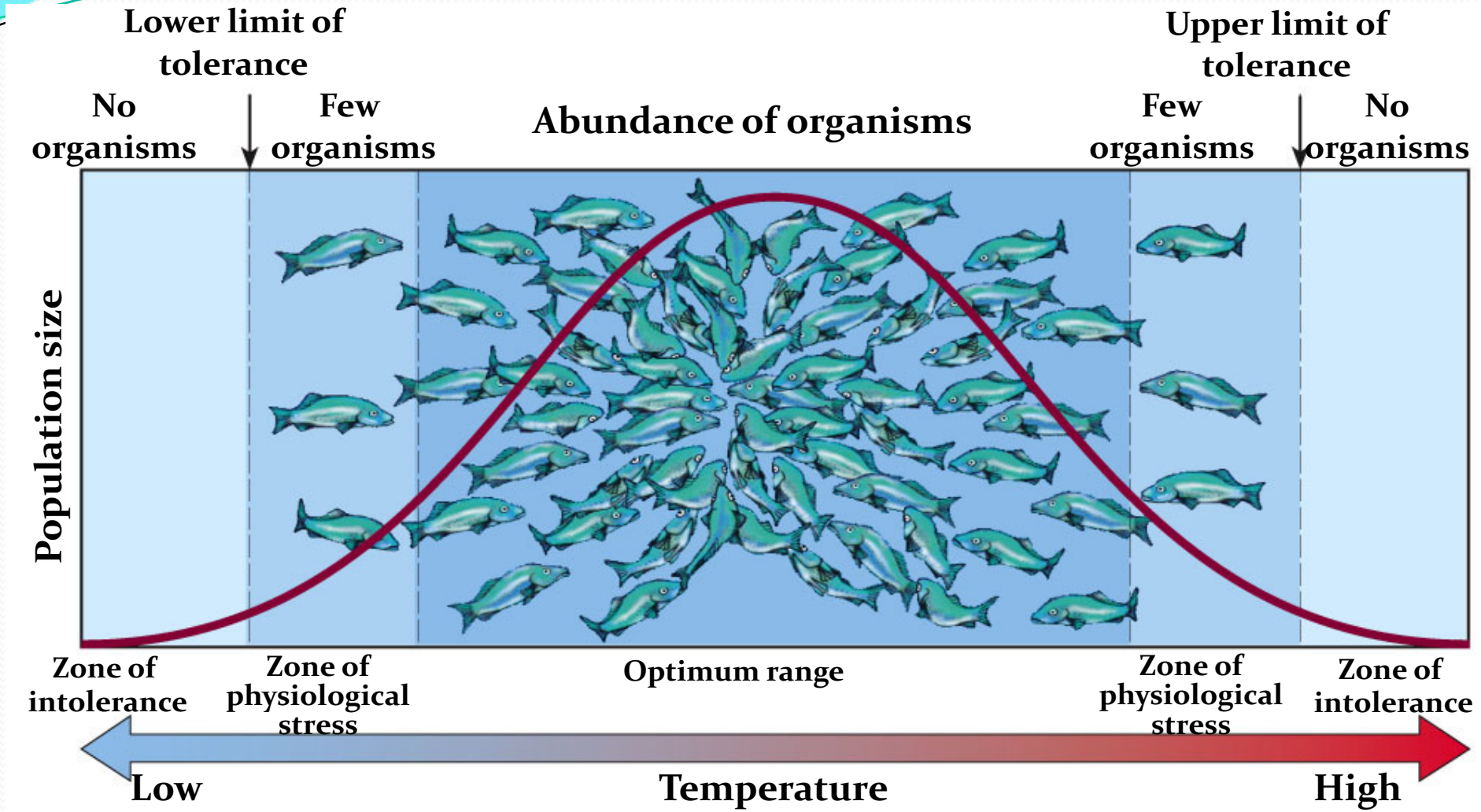
Key Terms

- Organism - any form of life
- Ecology - how organisms interact w/ one another and their non-living environment
- Symbiosis - 2 organisms living in close union
  - Parasitic - one organism benefits, but the other is harmed
    - moss on a tree
  - Mutualistic - both benefits each other
    - flowers & bees
  - Commensalism- one organism benefits, but the other is unchanged
    - fish hiding in coral reefs

Land portions of biosphere are classified into biomes

- Biomes: large regions such as forests, deserts and grasslands
  1. distinct climate
  2. specific life-form
  - More on these coming soon!
- Aquatic life zones:
  1. freshwater = lakes, streams
  2. marine = estuaries, coral reefs, oceans
- Ecotone
  - ecosystems rarely have distinct boundaries and are not self-contained
  - formed when one ecosystem merges with the next in a transition zone (when this # increases it is called an edge effect)

- **Law of Tolerance:**
  - **the existence, abundance, and distribution of a species is determined by physical and chemical conditions that a species can tolerate**
- **Limiting factor**:
  - too much or too little of an abiotic factor can limit or prevent growth of a population (precipitation is a key factor)
- Optimum level:
  - Exists for each abiotic factor
  - Can change relative to other abiotic factors



Aquatic limiting factors

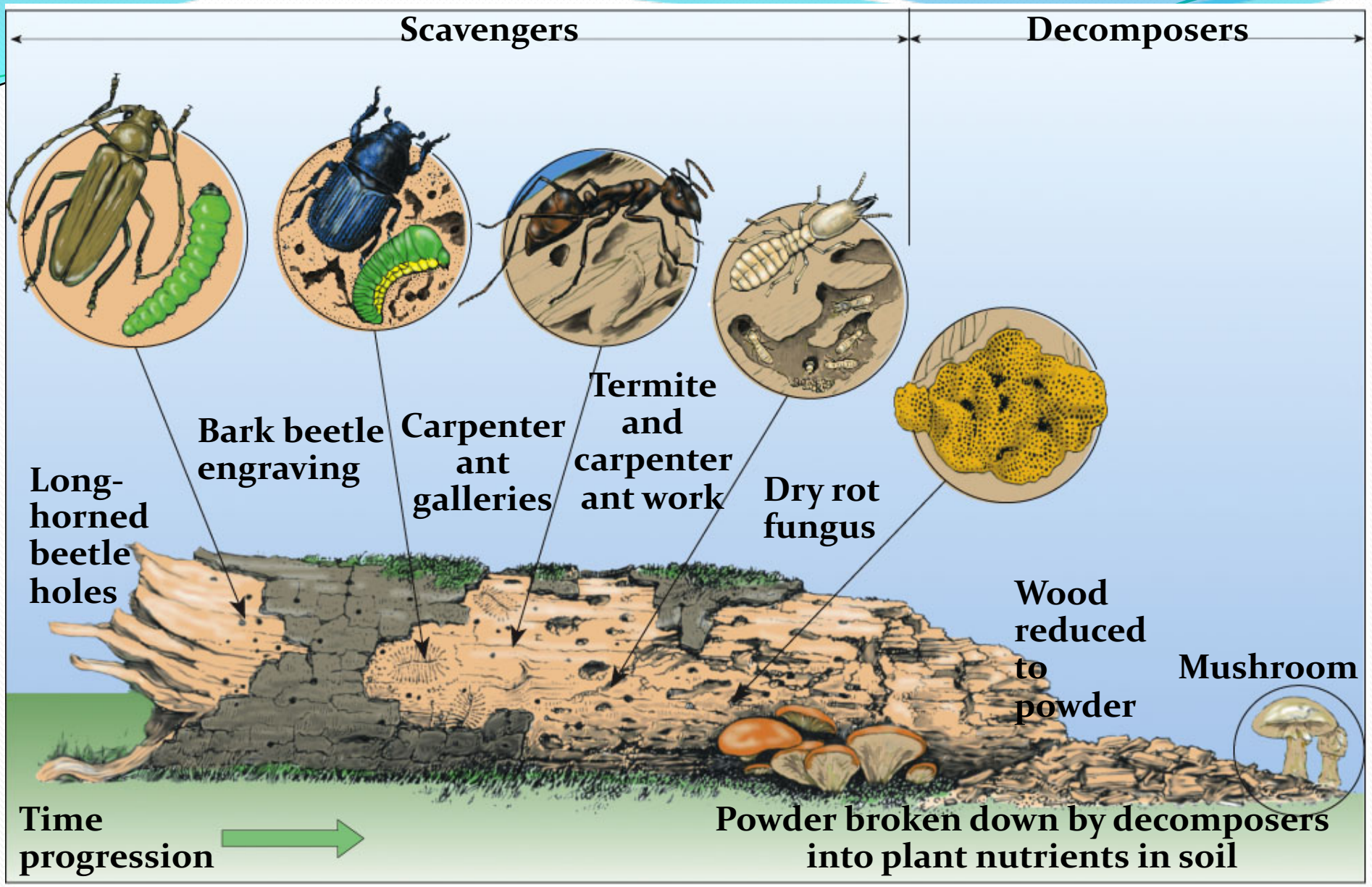
1. temperature
2. sunlight
3. dissolved oxygen content (amount of O2 in a given volume of water)
4. nutrient availability
5. salinity

Producers - make their own food

- Also known as **Autotrophs** or self-feeders
- Examples include
  - green plants
  - algae (marine)
  - phytoplankton (open algae)
  - Photosynthesis
    $CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$
    carbon dioxide + water w/ solar energy
    glucose + oxygen
  - Chemosynthesis
    - conversion w/out sunlight (uses geothermal energy)

Consumers - feed on other organisms

- **Heterotrophs** - (all others not producers)
  - Herbivores: plant eaters (primary consumers)
  - Carnivores: meat eaters (secondary consumers)
    - Some feed on other carnivores (tertiary consumers)
  - Omnivores: eat plants & animals (pigs, fox, bears)
  - Scavengers: eat dead organisms (vultures & flies)
  - Detritus: consume decomposed organic matter (crabs, termites)
    - Also may be considered scavengers
  - Decomposers: recycle organic matter (biodegrading)



Energy is released by

- **Aerobic respiration:**
  - uses oxygen to convert organic matter into CO_2 and water
  - opposite of photosynthesis
- **Anaerobic respiration** :
  - breaks down glucose in the absence of oxygen by cellular respiration
  - end products – methane gas, ethyl alcohol, acetic acid, hydrogen sulfide

Survival in an ecosystem depends on the flow of matter, energy & matter recycling.

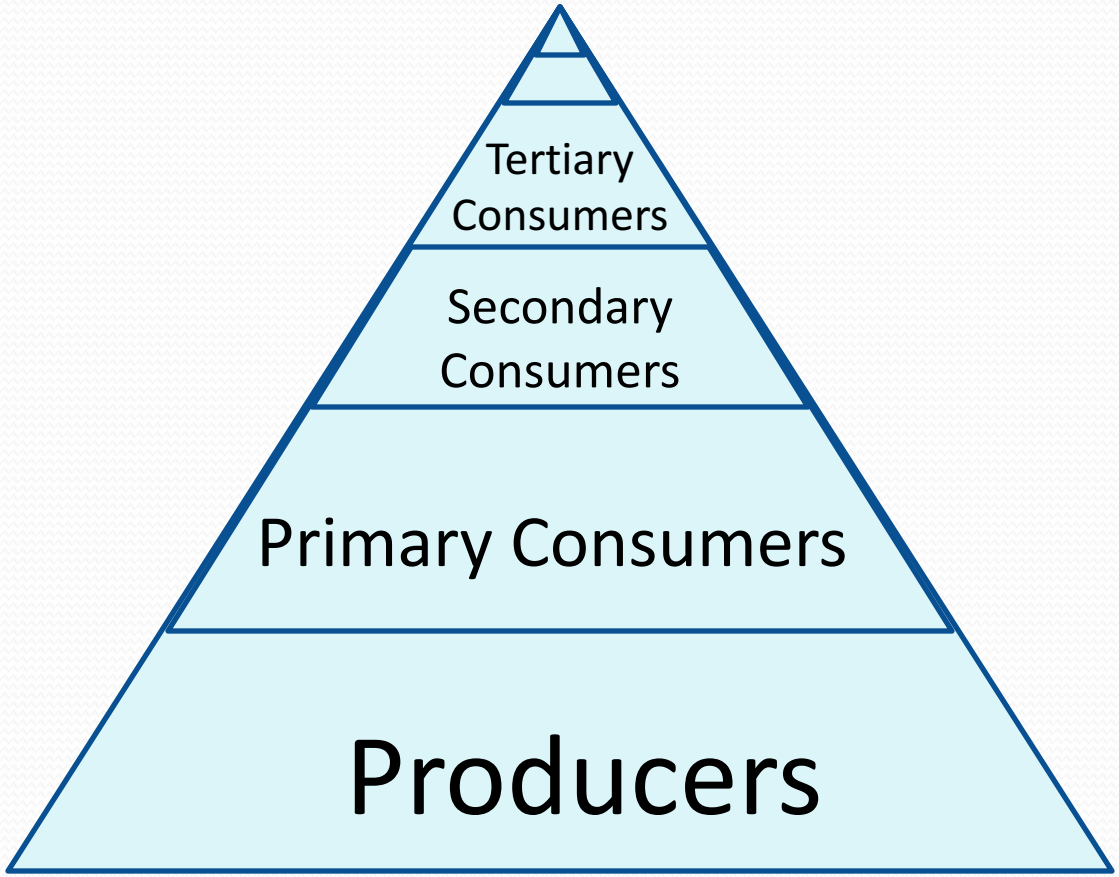
Biodiversity: insures a range of life forms that can best survive the variety of conditions on earth

- **genetic** diversity
  - variety in genetic makeup within a species
- **species** diversity
  - variety of species in different habitats
- **ecological** diversity
  - variety of forests, desert, grasslands, streams
- **functional** diversity
  - biological and chemical processes needed for species survival

FOOD WEBS AND ENERGY FLOW

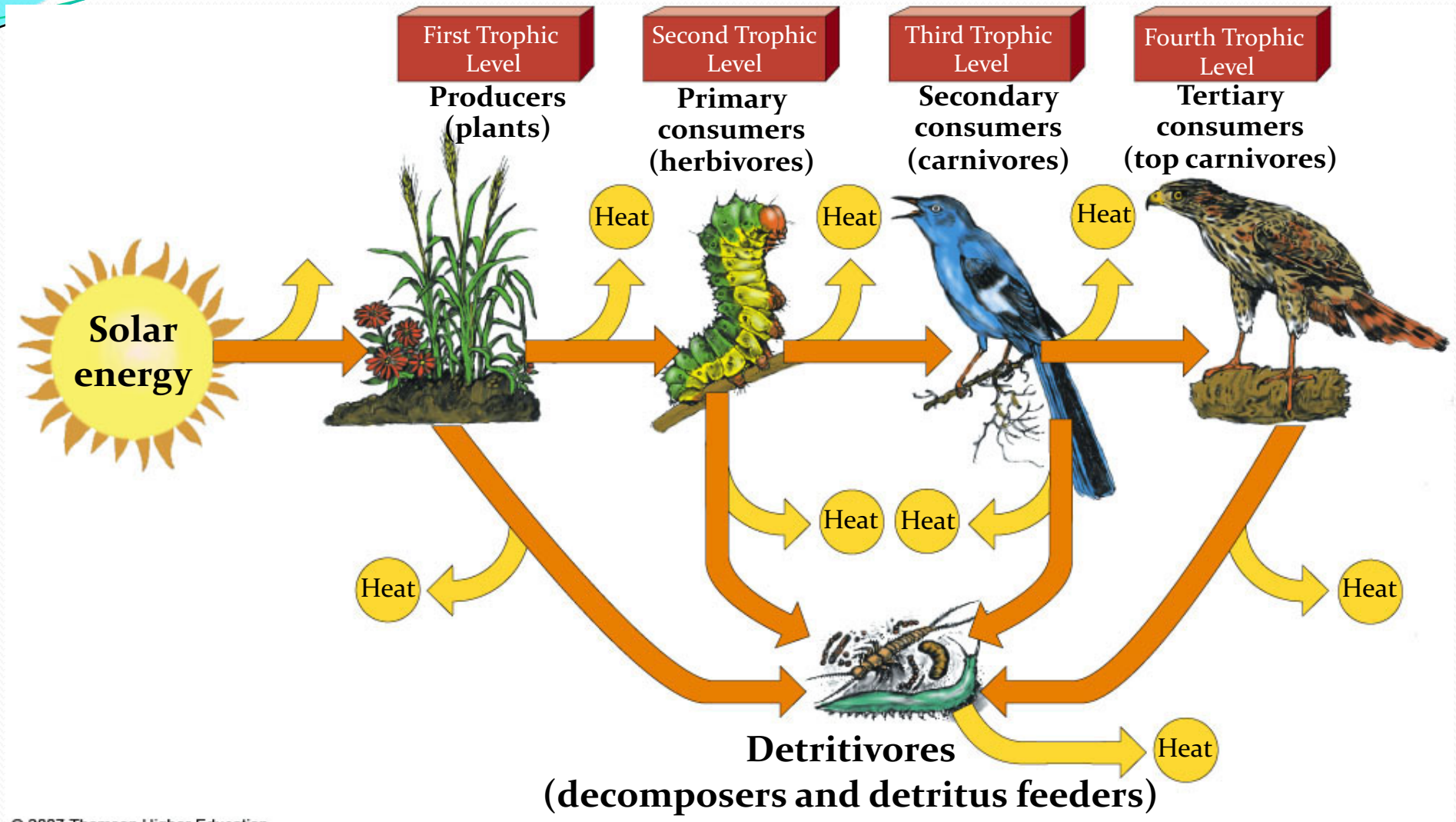
- **Food Chain:**
  - sequence of organisms each of which is a source of food for the next
  - energy is basic currency
- **Trophic level:**
  - ecologist assigned feeding levels depending on roles as producer or consumer, what it eats or decomposes
    - 1st level – producers
    - 2nd level – consumers
    - 3rd level – consumers of consumers
    - etc

Trophic pyramid



FOOD WEBS AND ENERGY FLOW

- **Food Web** : most species are in several different food chains (system of interconnected food chains)
- **Biomass:** the dry weight of all organic matter contained in its organisms
  - in other words the total combined weight of all the organisms at each trophic level
- **Ecological efficiency**: the % of usable energy transferred as biomass from 1 level to another (typical loss is 90% at each level)
- **Pyramid of energy flow**: illustrates energy loss (90%)
  - Always has an upright pyramidal shape
  - Shows why Earth can support more people if they are at lower trophic levels



Primary Productivity of Ecosystems

- **GPP (Gross primary productivity)**
  - ecosystems producers convert solar energy into chemical energy as biomass
  - varies,
    - greater in shallow water such as coral reefs
    - less in deserts or open ocean
- **NPP (Net primary productivity – what you have access to)**
  - what is left after producers use
  - Ag land is highly managed
    - man can **raise** the NPP by adding fertilizers to promote growth (nitrates, phosphates etc), OR **lower** NPP by removing forest

Matter cycles into & through a system

- **Closed system** – energy but not matter is exchanged between system and environments

- **Open system** – takes in matter and energy, gives off matter and energy

- **Ecologists estimate that humans use, waste & destroy % of earth's potential & % of earth's land ecosystems**

Earth's life support systems:

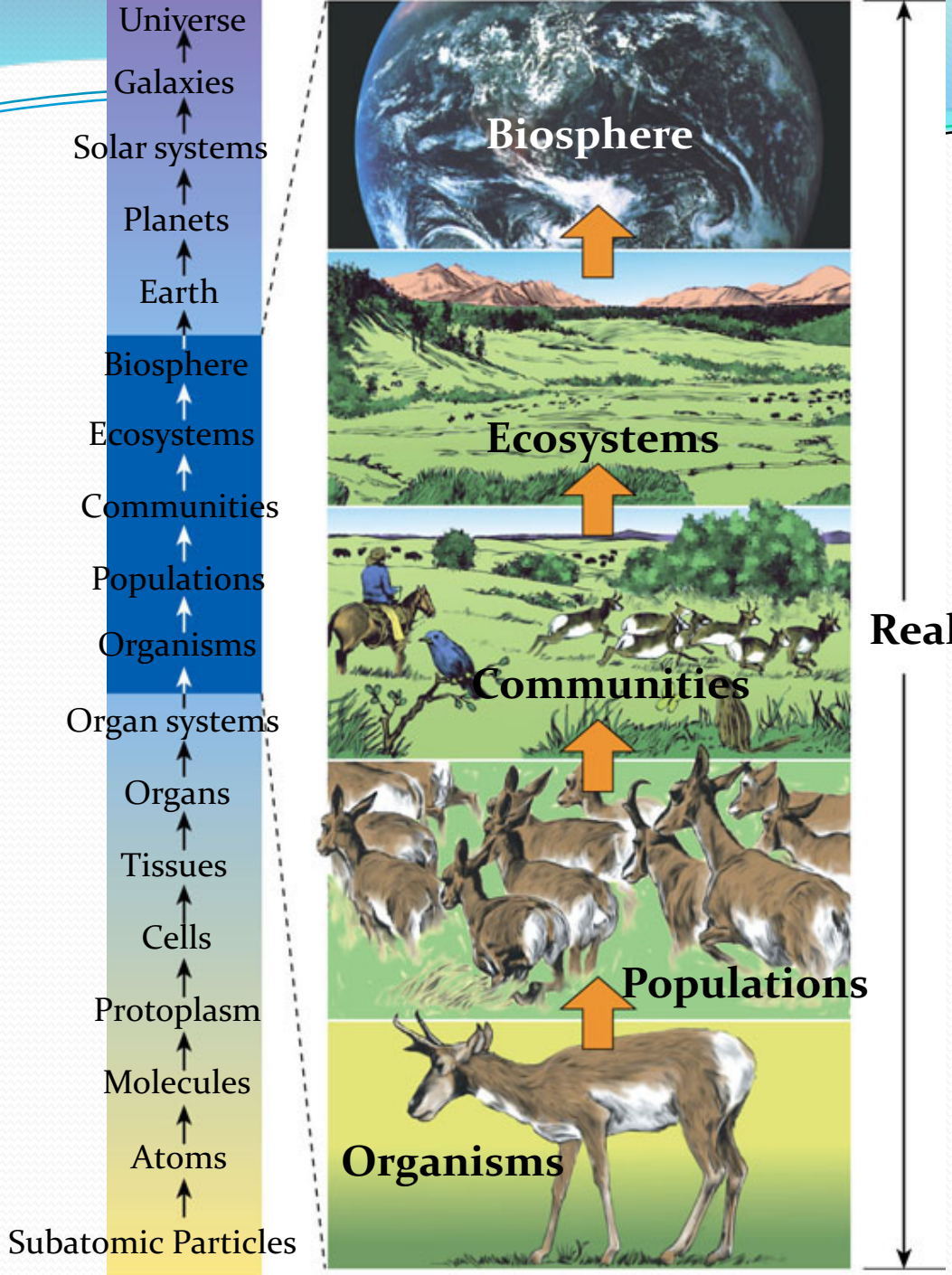
- **Atmosphere** :
  - thin envelope of air around the planet
  - Divided into regions including
    - Troposphere - inner layer N 78% O_2 21%
    - Stratosphere – next layer out, lower portion contains "good" ozone
      - ozone is "good up high, bad below"
    - And others we won't discuss right now
- **Hydrosphere**:
  - earth's liquid water, ice, icebergs, & water vapor in atmosphere
- **Lithosphere**:
  - earth's crust & upper mantle
  - Includes non-renewable fossil fuels, minerals, soils
- **Biosphere**:
  - Where living organisms interact w/ nonliving environment including hydrosphere, lower atmosphere, and upper lithosphere

Terms to know

- Ecology
- Ecosystem
- Organisms
- Cell
  - Eukaryotic
    - membrane & nucleus
  - Prokaryotic
    - bacteria & microorganisms
- Species:
  - Sexual reproduction
    - Combining sex cell from both parents
    - Higher chance of survival under changing environmental conditions
  - Asexual reproduction
    - Divides to produce 2 identical cells that are clones of originals

Terms to know

- **Population:**
  - group on interacting individuals of the same species that occupy a specific area at the same time
  - ex: fish in a pond, people in a country
- **Classification**:
  - biosphere
  - ecosystems
  - communities
  - populations
  - organisms
- **Genetic Diversity** :
  - slight variation in the genetic makeup in a natural population
  - in response to change in environmental conditions, change size, age populations distribution, density, genetic composition
- **Habitat**
  - place where a population or organism normally lives
- **Community**
  - populations of a different species occupying a particular place



Life on earth depends on 3 interconnected factors

1. **One-way flow of high-quality energy from the sun**
   - then into living things in their feeding interaction
   - into the environment as low-quality energy
   - eventually back into space as heat
2. **Cycling of Matter**
   - atoms, ions or molecules needed for survival by living organisms throughout parts of the biosphere
3. **Gravity**
   - allows planet to hold onto atmosphere
   - causes downward movement of chemicals in matter cycles

Ecological Niche and Population of Species

Ecological niche

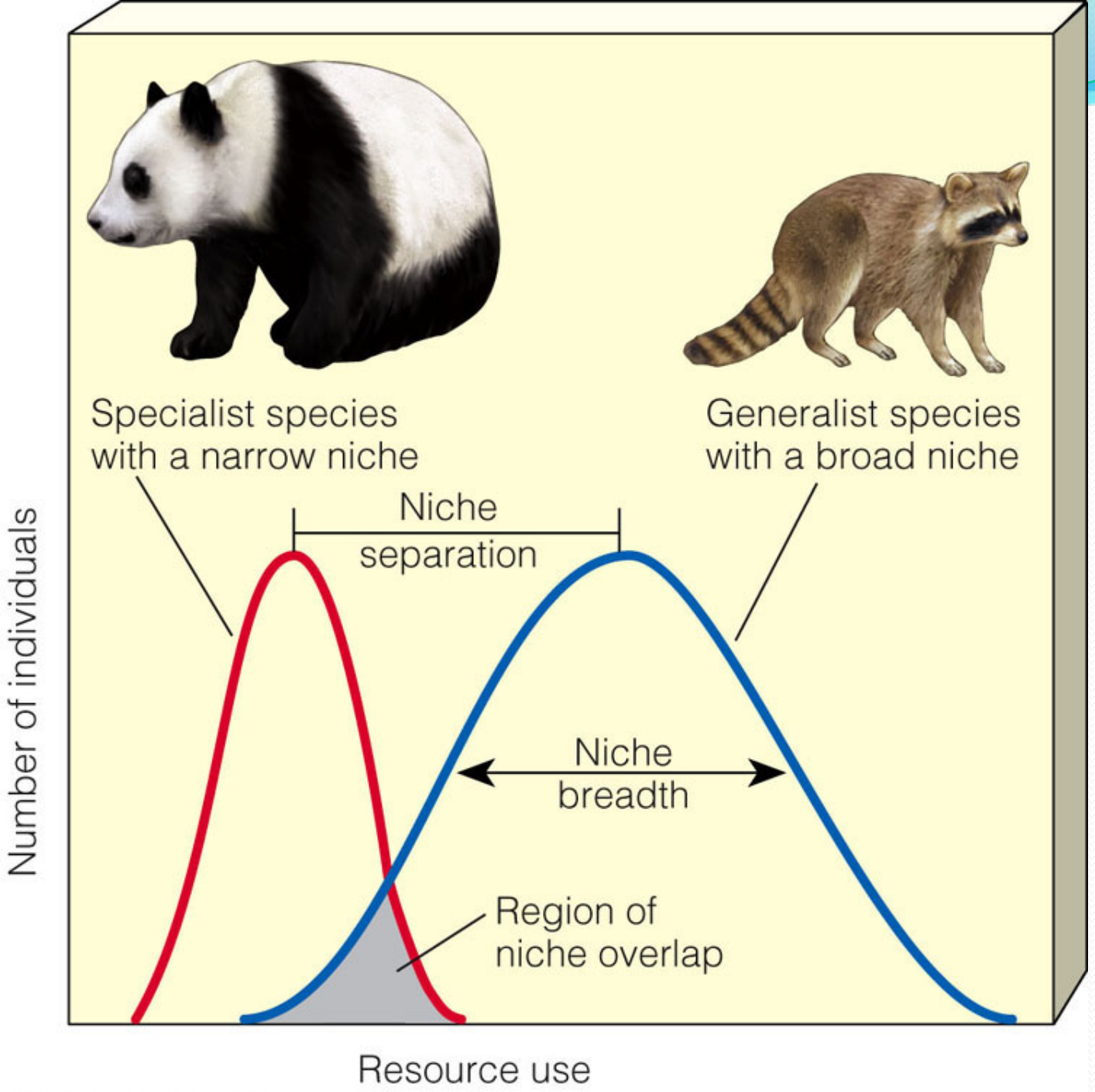
- **Ecological niche**: a species way of life or functional role in an ecosystem range of tolerance for physical and chemical conditions
  - types and amounts of resources it uses
  - how it interacts with other living things
  - role it plays in the energy flow and matter cycling

Ecological niche

- **Fundamental niche**: full potential range of physical, chemical and biologic
  - What it is with no competition
- **Realized niche**: species occupies only part of its fundamental niche to survive and avoid competition for same resources
  - How it actually happens

Ecological niche

- **Generalized species**: have broad niches can live in many different places
  - eat a variety of foods
  - tolerate a wide range of environmental conditions (flies, cockroaches)
- **Specialized species**: have narrow niches live in only one type of habitat
  - use only one or a few types of food
  - tolerate only a narrow range of climatic and other environmental conditions (spotted owls)



SPECIATION, EXTINCTION & BIODIVERSITY

- **Speciation**: natural selection can lead to an entirely new species
  - Geographic isolation: physical barriers
  - Reproductive isolation: 2 geographic isolated populations evolve with a different genetic makeup: cannot breed with other and will produce nonliving offspring
- **Extinction**: when environmental conditions change a species must either
  1) evolve
  2) move to a favorable area
  3) cease to exist

SPECIATION, EXTINCTION & BIODIVERSITY

- **Background extinction**: species disappear at a low rate
  -caused by environmental disaster, humans
- **Mass extinction**: significant rise in extinction rates
  -caused by a global event (25-75% wiped out)
- **Adaptive radiations**: mass extinctions have been followed by periods of recovery: where new species evolve
  - Happen after mass extinction to fill available niche
- **Biodiversity**: speciation minus extinction equals biodiversity - the planets genetic raw material for future evolution in response to changing environmental conditions

POPULATION OF SPECIES

- Population dynamics: population change is in response to environmental conditions:
  1. size
  2. density
  3. dispersion
  4. age distribution
- Variables that limit population growth:
  1. births
  2. deaths
  3. immigration
  4. emigration

Population change = (births + immigration) – (deaths + emigration)

POPULATION OF SPECIES

- **Biotic potential:** populations vary in their capacity for growth
- **Intrinsic rate of increase:** rate at which a population would grow if it had unlimited resources.
  1. reproduce early in life
  2. have a short generation times
  3. can reproduce many times (long reproductive life)
  4. emigration

  The ancestors of a single female housefly could total 5.6 trillion within 13 months.

POPULATION OF SPECIES

There are always limits to population growth in nature

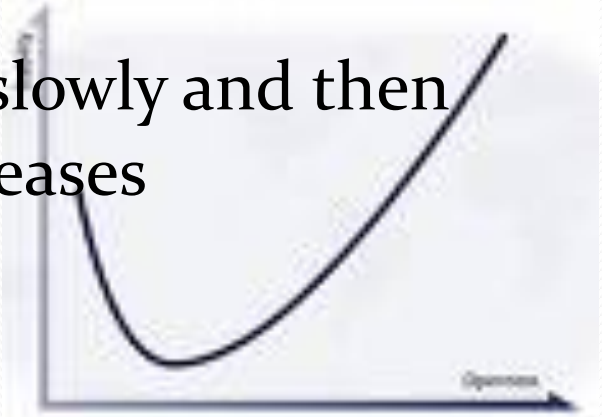
- **Environmental resistance:** factors that limit growth of a population
  Size in a given place is determined by the interplay between biotic potential and environmental resistance
- **Carrying capacity (K):** number of individuals of a given species that can be sustained indefinitely in a given space (area or volume)

If a population declines below the MVP (minimum viable population)

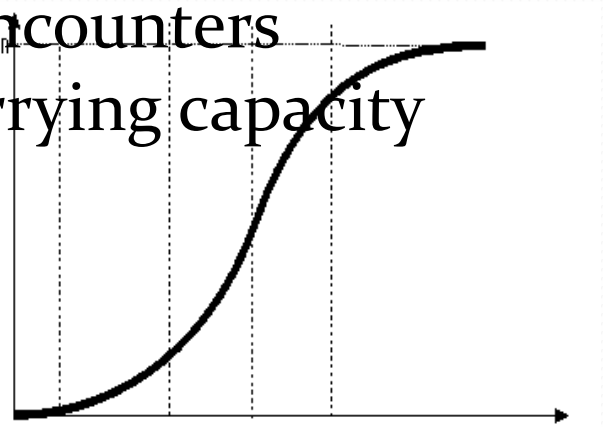
1. certain individuals may not be able to locate mates
2. genetically related individuals may interbreed and produce weak or malformed offspring
3. genetic diversity may be too low to enable adaptation to new environmental conditions

POPULATION OF SPECIES

- **Exponential growth:** starts out slowly and then proceeds faster as population increases
  - Yields J curve over time

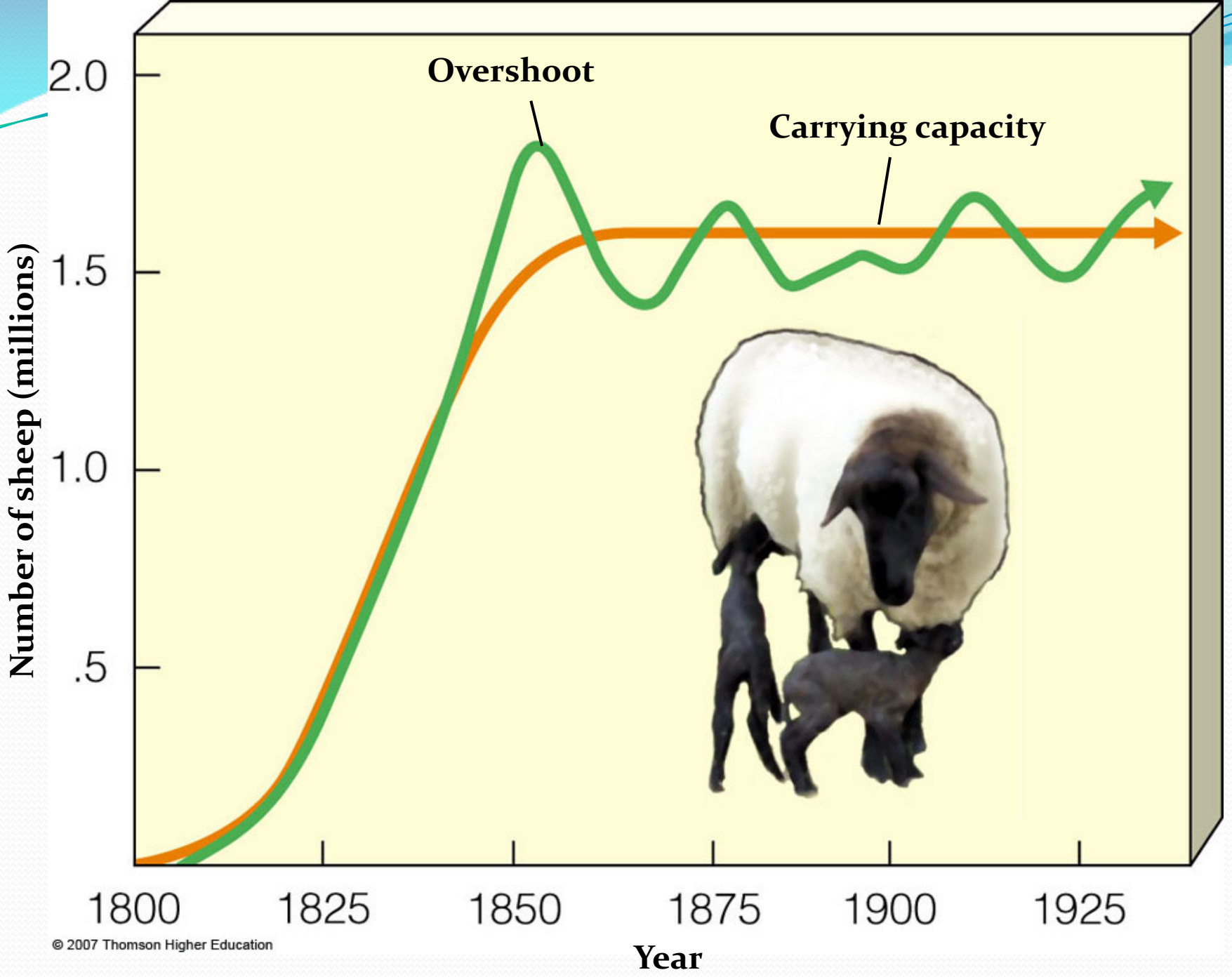


- **Logistic growth:** steady decrease in population growth with time as the population encounters environmental resistance, reaches carrying capacity and then levels off
  - Yields S curve over time



POPULATION OF SPECIES

- Carrying capacity is affected by:
  1. Competition within species
  2. Immigration and emigration
  3. Natural and human-caused catastrophic events
  4. Seasonal fluctuations
- If population exceeds carrying capacity it overshoots or exceeds environmental resources
  - (Easter Island, Ireland in 1845 potato crop destroyed by fungus)


Overshoot
Carrying capacity
2.0
1.5
1.0
.5
Number of sheep (millions)
1800
1825
1850
1875
1900
1925
Year
© 2007 Thomson Higher Education

Population density affects population growth

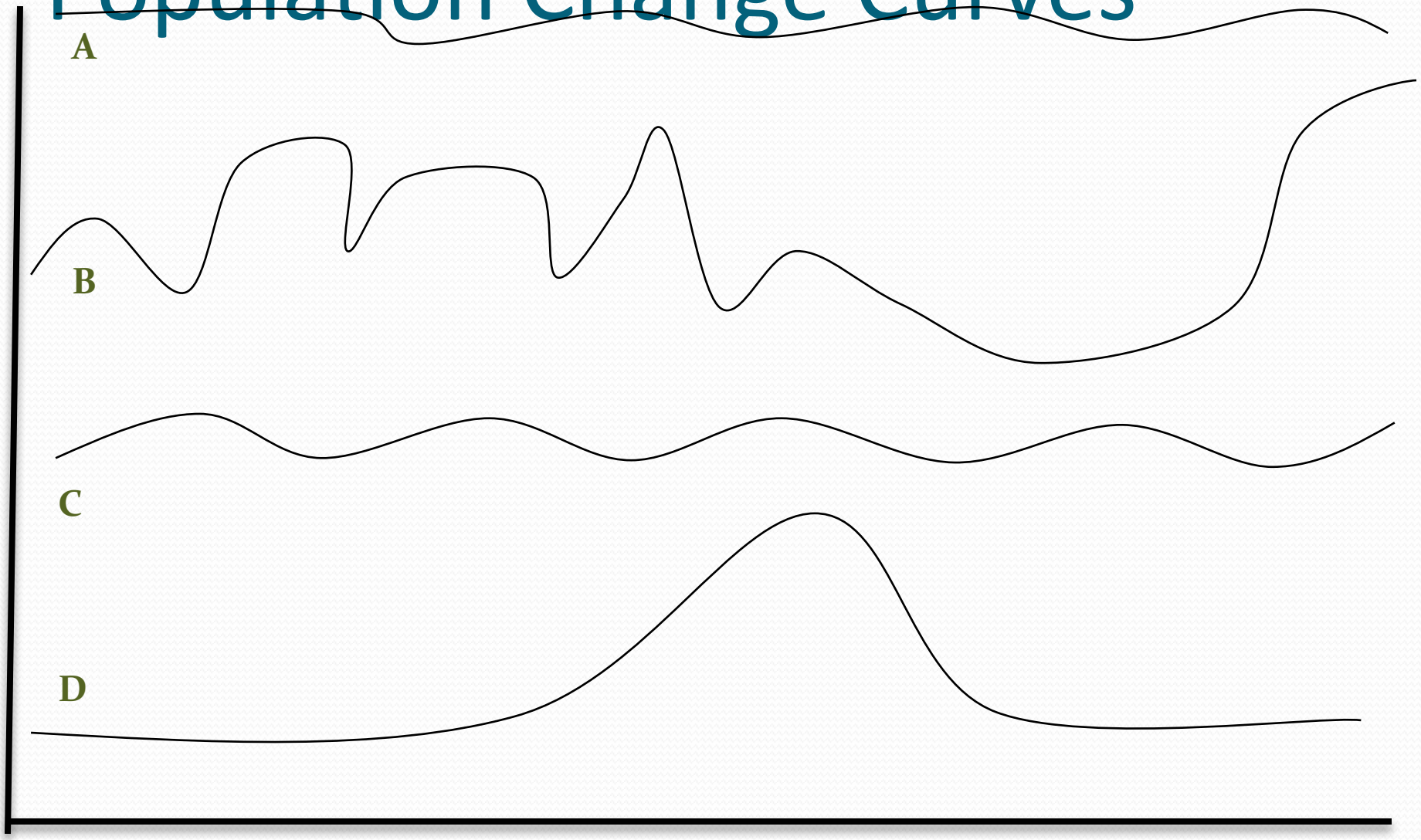
- **Density – independent population controls:** affect size regardless of population
    1. floods
    2. fires
    3. hurricanes
    4. unseasonable weather
    5. habitat
    6. pesticide spraying
- Some limiting factors have greater effect as population density increases: **density-dependent population controls**
    1. Competition for resources
    2. predations
    3. parasitism
    4. disease

Population change curves in nature

1. stable: slight fluctuation above and below carrying capacity
2. irrupt: fairly normal but suddenly erupts and then crashes
3. irregular: no known pattern
4. cyclic: fluctuations over a regular time period

boom –bust cycles

Population Change Curves



Predators and population size

Lynx-Hare Cycle Top down control
Bottom up control

- Top down:
  - Lynx preying on hares reduce the population
  - Shortage of hares reduce lynx population
- Bottom up:
  - Hares die from overconsumption
  - Plants recover
  - Hare populations rises

Community Ecology

Community Ecology

- COMMUNITY STRUCTURE: structure or spatial distribution of its individuals and populations.
- 4 basic characteristics:
  - physical appearance: relative size, stratification and distribution can be vertical or horizontal
  - species diversity: number of different species
  - species abundance: number of individuals of each species
  - niche structure: number of niches, how they differ, how they interact

Community Ecology

- **Edge effects:** differences in physical structure and properties (ie. Sun, temp, wind and humidity) at boundaries and in transition zones between 2 ecosystems.
  - Edges will be different than interiors.
  - Wild game animals are more plentiful at edges (makes species more vulnerable)
- **Most of the World's Biodiversity:**
  1. Tropical rain forests
  2. coral reefs
  3. deep sea
  4. large tropical lakes

Community Ecology

- **Factors affecting Species Diversity**
  1. Latitude for terrestrial systems
  2. Depth-for aquatic systems
  3. Pollution

Species diversity increases with :

1. increased solar radiation
2. increased precipitation
3. decreased elevation
4. pronounced seasonal variations

What Determines the number of species on islands?

- Size and degree of isolation
- **Species equilibrium model**: # of species found on an island determined by
  1. The rate at which new species immigrate to the island
  2. the rate at which species become extinct
- Immigration and extinction depend on size and distance from the nearest mainland
- At some point should reach equilibrium

GENERAL TYPES OF SPECIES

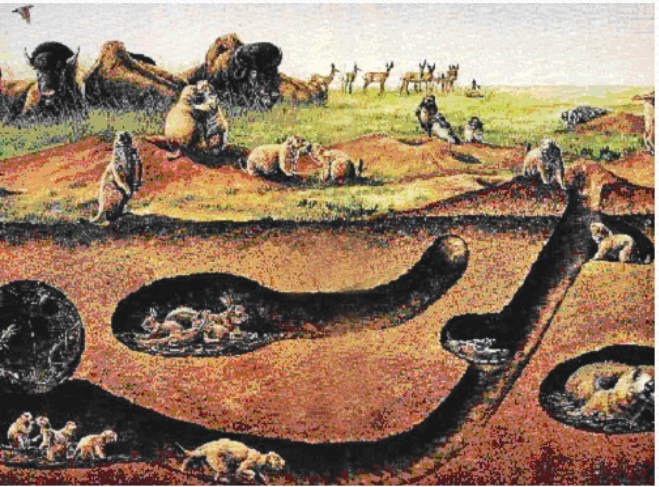
- Roles species play in Ecosystems:
  - **Native species**: normally live and thrive in a particular ecosystem
  - **Nonnative species**: migrate either deliberately or accidentally
    - (African bees-have moved up through Central A., Mexico, should be killed off when they hit winters in central US)
  - **Indicator Species**: early warner's of damage to community (birds, trout)
  - **Keystone Species**: play pivotal roles in structure and function
    - strong interactions with other species affect survival of those species
    - process material out of proportion to their #'s and biomass
      - Disproportionate effect relative to its abundance

Keystone species

- A species whose very presence contributes to diversity of life and whose extinction would lead to extinction of other life
- Roles played include
  1. Pollination of flowering plants
  2. Dispersion of seeds
  3. Habitat modification
  4. Predation
  5. Improving ability of plants to obtain soil, minerals and water
  6. Efficient recycling of animal waste

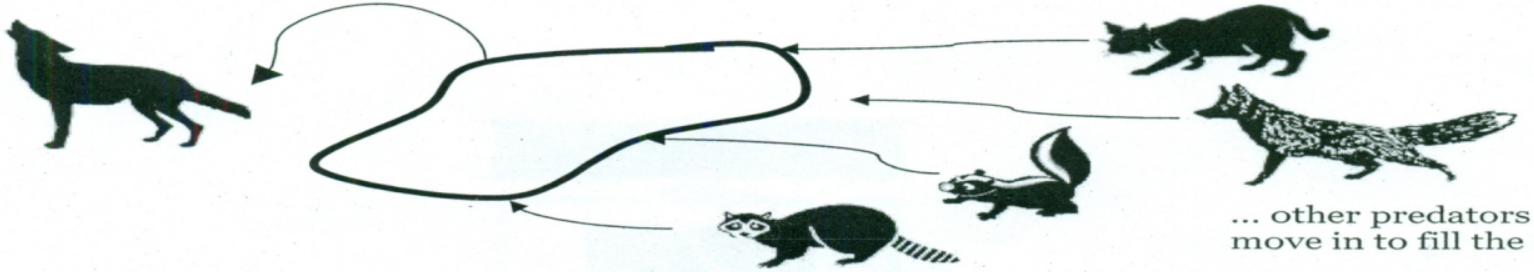
Keystone species

- An example: **prairie dogs**
  - Are eaten by coyotes etc
  - Burrows provide a home for other species
  - Eating habits encourage broad leaf vegetables which brings wildlife



1.

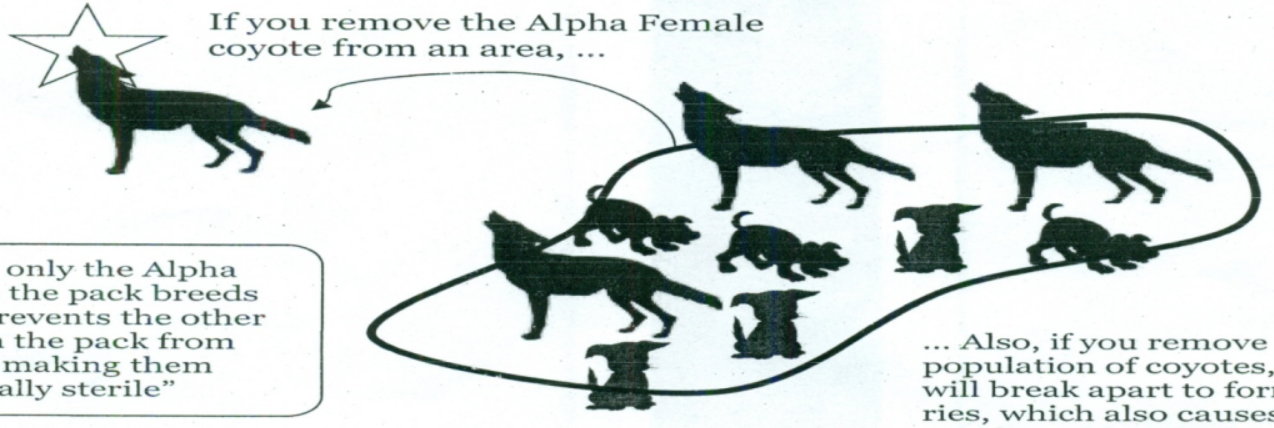
If you remove coyotes from an area, ...



... other predators will move in to fill the niche

2.

If you remove the Alpha Female coyote from an area, ...

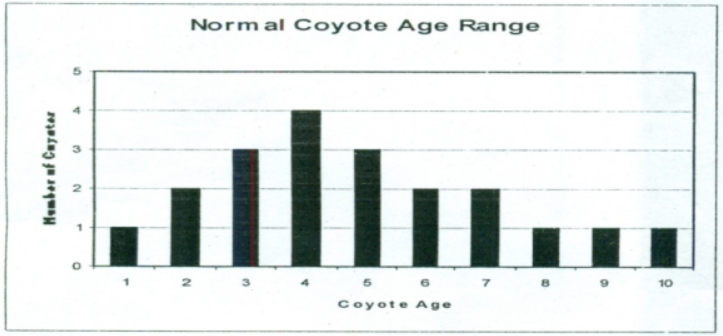


... Then the other females in the pack will begin to breed and rapidly increase the population.

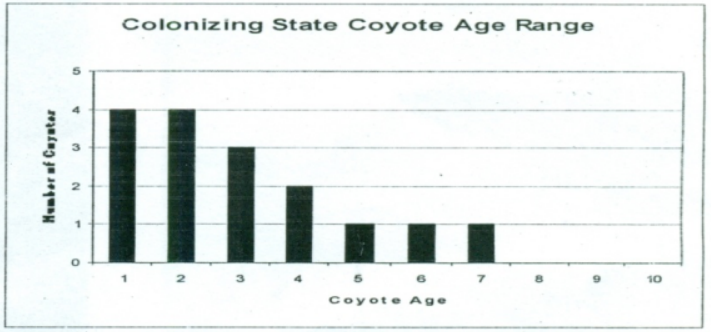
Typically, only the Alpha Female in the pack breeds and she prevents the other females in the pack from breeding, making them "behaviorally sterile"

... Also, if you remove less than 70% of the population of coyotes, then the coyote packs will break apart to form more smaller territories, which also causes an increase in the total number of females breeding, and therefore rapidly increase the population.

3.



In a normal coyote population, the average age is 4 and reproduction declines at age 6. So older alpha pairs keep their territories, but do not reproduce.



But when coyotes are removed from an area, it causes them to go into a "Colonzing State" where there are more younger coyotes with no limitations on breeding and so they rapidly increase the population.

Competion and predation

- Species interaction:
  - be harmed by
  - benefit from
  - be unaffected by
- 5 basic types:
  1. Interspecific competition
  2. Predation
  3. Parasitism
  4. Mutualism
  5. Commensalisms

Competion and predation

- Same species competition: **Intraspecific competition**: same species; same resources
  - (ex: plant pherones, wind seed dispersal, territoriality)
- Different species competition: **Interspecific competition:** different; same resources
  - With significant niche overlap, one species may have to
    1. migrate to another area
    2. shift its feeding habits through evolution and natural selection
    3. decline in population
    4. become extinct

Competion and predation

- Interference competition: one species may limit another's access
  - Ex: chemical/toxin release
- Exploitation competition: same access but differ in how fast or efficiently they use it
  - Ex: Humans – space/food

- **Competitive Exclusion Principle**

When one species eliminates another species in an area through competition for limited resources.

Competion and predation

- **Resource Partitioning** - The dividing of resources so that species with similar needs use them
  1. at different times
     - Hawks vs owls, butterflies vs moths
  2. in different ways
  3. in different places
     - Ground vs treess
- Each of the competing species occupies a *realized niche* that makes up part of its *fundamental niche*

  *in effect, they evolve traits that allow them to share the wealth


60
40
20
0
Foraging height (ft)
Cape May warbler
Blackburnian warbler
Black-throated green warbler
Bay-breasted warbler
Yellow-rumped Warbles (Audubon form- West)

Predator and Prey Interaction

- **Predation**: members of one species (predator) feed on all or part of a living organism of another species (prey). Prey may or may not die.
- Reducing prey population gives remaining prey access to food supply and can improve genetic stock
- How predators get food:
  - Herbivores can walk, swim or fly to plants
  - Carnivores: pursuit & ambush

Predator and Prey Interaction

- Prey Defense:

1. ability to run, swim or fly fast
2. highly developed sense of sight or smell
3. protective shells
4. thick bark (sequoia)
5. spines
6. camouflage
7. chemical warfare (oleanders – bad taste/smell)
8. warning coloration: toxic
9. scare off predator: blowfish, peacock

sYMBIOTIC SPECIES INTERACTIONS

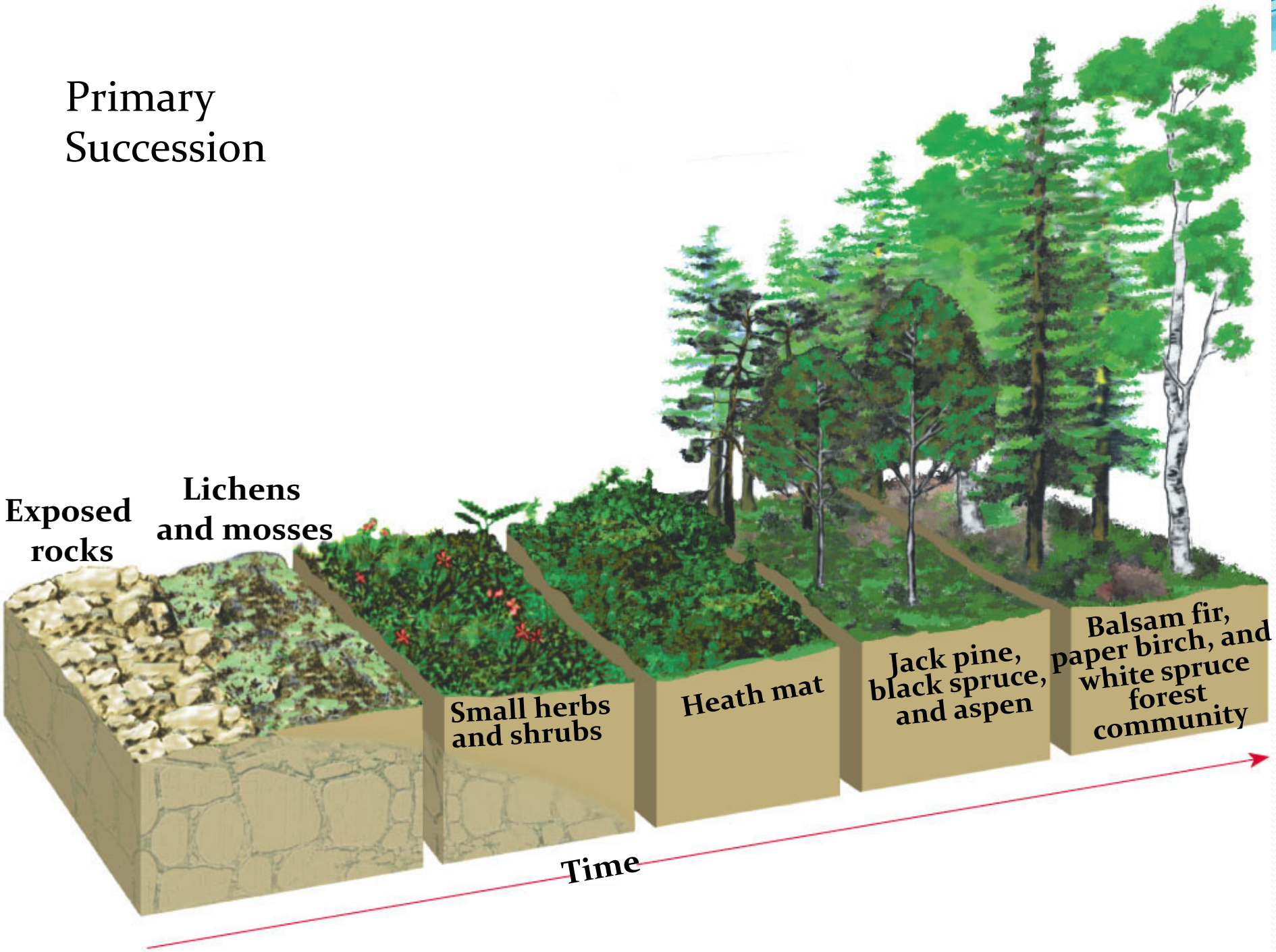
- **Symbiosis**: species live together in an intimate association
- **3 types**:
  1. **Parasitism**: usually smaller than host draws nourishment from and weakens host
     - rarely kills host (ex: tapeworms, moss)
  2. **Mutualism:** species that interact in a way that benefits both
     - dispersing pollen and seeds for reproduction
     - supply food (ex: lichen)
     - receive protection (ex: guard dogs)
  3. **Commensalism:** benefits one species but neither harms or helps other
     - herbs under tree
     - Epiphytes (orchid)

ECOLOGICAL SUCCESSION

- Ecological succession is the gradual change in species composition of a given area.

- **Primary succession:** gradual establishment of communities on nearly lifeless ground
  - Begins where there is no soil or ecosystem
  - Soil begins when **pioneer species** attach themselves to inhospitable patches of bare rock and start the soil formation process
- **Early succession plant species:** grow close to ground, large populations, have short lives.
- **Midsuccessional plant species:** herbs, grasses, low shrubs
- **Late successional plant species:** trees that tolerate shade

Primary Succession



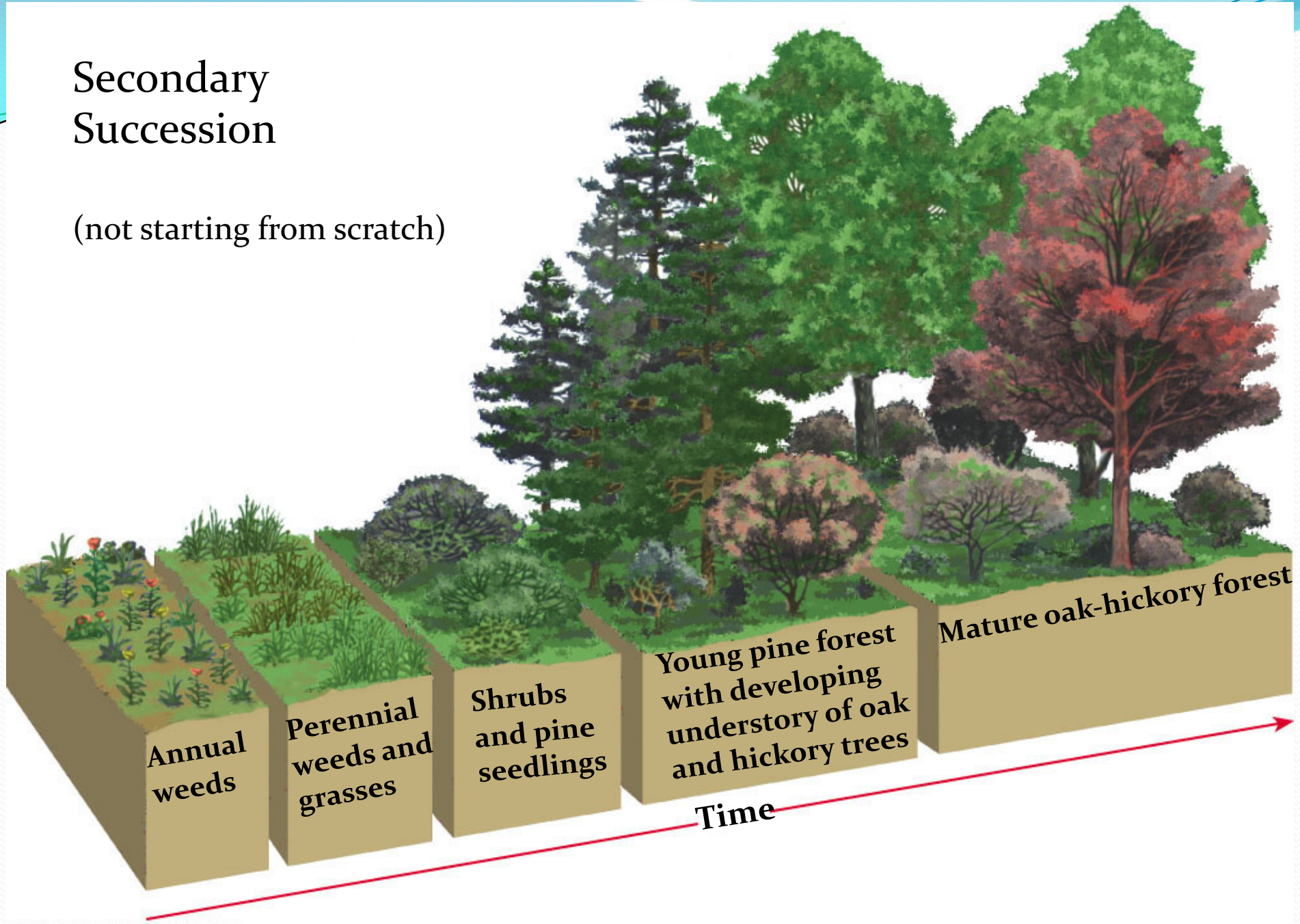
ECOLOGICAL SUCCESSION

- **Secondary succession:** reestablishment of biotic communities in an area where some type of biotic community is already present.

- There was a disturbance from fire etc.
  - Candidates include:
    - abandoned farmlands
    - cut forests
    - polluted streams
    - floods

Secondary Succession

(not starting from scratch)



ECOLOGICAL SUCCESSION

- **Species replace one another in ecological succession**
  - facilitation: one set of species makes an area suitable for species with different niche requirements
  - inhibition: early species hinder the establishment and growth of other species.
  - tolerance: late plants are unaffected by pearlier plants

ECOLOGICAL SUCCESSION

- **Intermediate Disturbance Hypothesis**
  - Communities that experience fairly frequent but moderate disturbances have the greatest species diversity.
- **Balance of Nature:**
  1. dominated by a few long-lived plants species
  2. in balance with its environment
- **Climax community:** area is predictable and stable

ECOLOGICAL STABILITY AND SUSTAINABILITY

- **Stability** is maintained only by constant dynamic change in response to changing environment conditions
  1. **inertia** or persistence: the ability of a living system to resist being disturbed or altered
  2. **constancy**: the ability of a living system such as a population to keep its numbers within the limits imposed by available resources
  3. **reliance**: the ability of a living system to bounce back after an enternal disturbance that is not too drastic.
- Rarely are ecosystems in equilibrium but in a continuing state of disturbance, fluctuation and change.

The precautionary principle

- *Precautionary Principle: when evidence indicates that an activity can harm human health or the environment, we should take precautionary measures to **prevent** harm even if some of the cause-and-effect relationships have not been fully established scientifically.*

- Common sense ideas formed on basis of global treaty developed by 122 countries in 2000 to ban or phase out 12 persistent organic pollutants.
  - UN convention on Biodiversity
  - Cartagena Protocol ratified in 2003