COMMUNITY ECOLOGY

Community Ecology Lecture

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Community Ecology Objectives

1. Define community ecology and recognize species that affect community structure.
2. Describe possible relationships and interactions between species within a community.
3. Conceptualize how energy and matter flow through, support, and are transferred within a community.
4. Identify defining characteristics of community structure and dynamics.

Objective 1: Define community ecology and recognize species that affect community structure.

What is a community?

Populations of different species living and interacting in a common area. This can be plants, animals, and all other forms of living organisms.

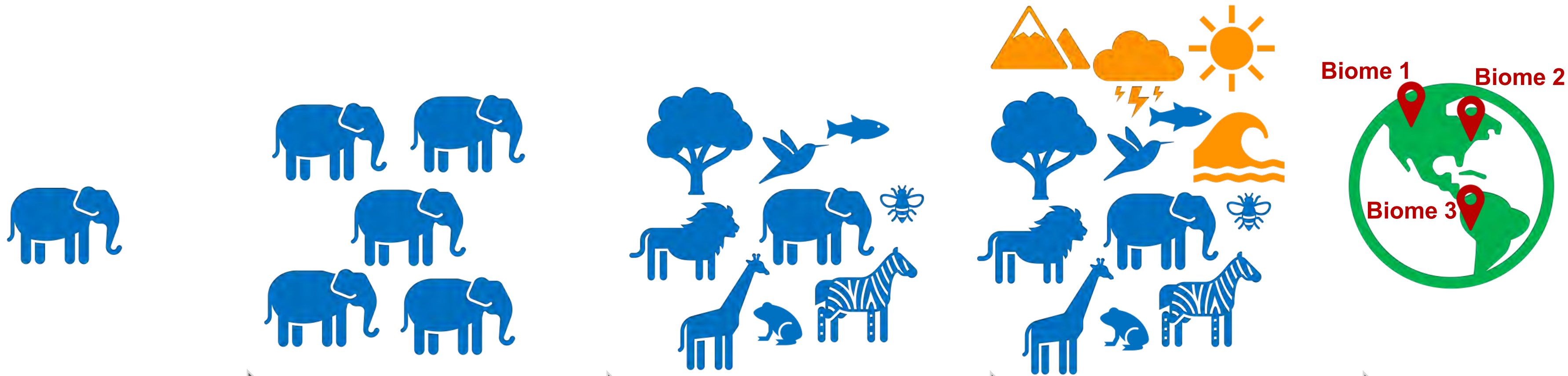
Community ecology is the study of these communities.

Community ecologists ask questions regarding;

- Biodiversity
- Community structure
- Abundance of species
- Distribution of species
- Species interactions

Hierarchy of Life on Earth

biotic | biotic | biotic | abiotic + biotic | abiotic + biotic



Organism → **Population** → **Community** → **Ecosystem** → **Biome**

Organism: A living individual organism

Population: Many individuals of the same species that can breed and produce offspring

Community: Many individuals from different species interacting with one another

Ecosystem: A community and all its abiotic components

Biome: Ecosystems that occupy a large geographic area

Niche = the position or function a species plays within its community; including how it gets its energy and nutrients, its habitat requirements, how it survives and reproduces, and the other species or parts of the ecosystem that it interacts with

Definition adapted from Environmental Science for a Changing World

Niche Specialists versus Niche Generalists

A specialist is a species with a very specific habitat or resource requirements that can restrict where it can live.

A generalist is a species who occupies a broad niche because it can utilize a wide variety of resources.

Keystone Species = a species that impacts its community more than its mere abundance would predict, often altering ecosystem structure

Definition adapted from Environmental Science for a Changing World

Typical traits:

- May provide a unique service
- Other species and the ecosystem depend on keystone species to survive and reproduce
- If lost would create a “ripple effect” within community leading to less healthy community as a whole

Keystone Species

Scientists often recognize three types of keystone species:

Predators

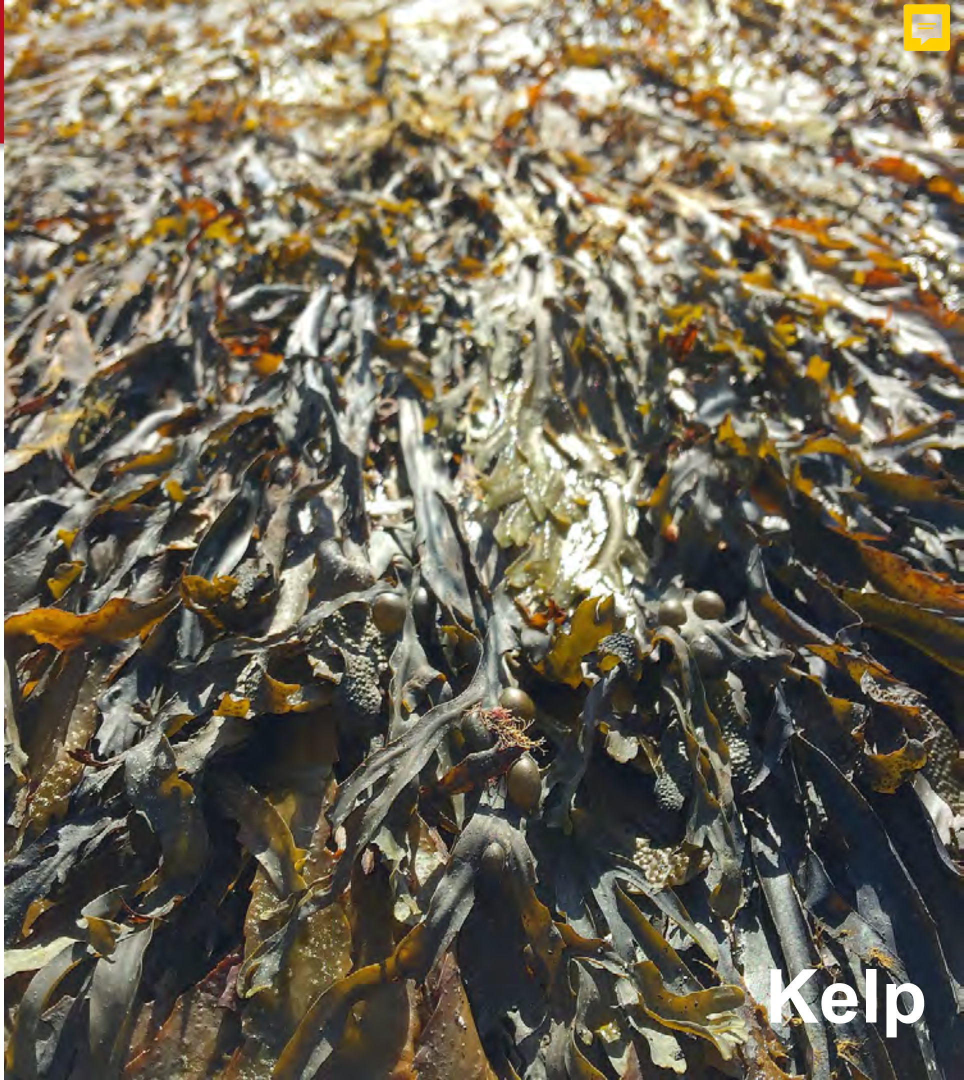
Ecosystem Engineers

Mutualists

Foundation Species = a species that has a strong role in structuring a community by creating and maintaining habitat

Typical traits:

- Abundant in number and account for significant biomass in a system
- Copious connections to numerous other species



Invasive Species = a species that was introduced to an area and is not native, and which typically does damage to the environment

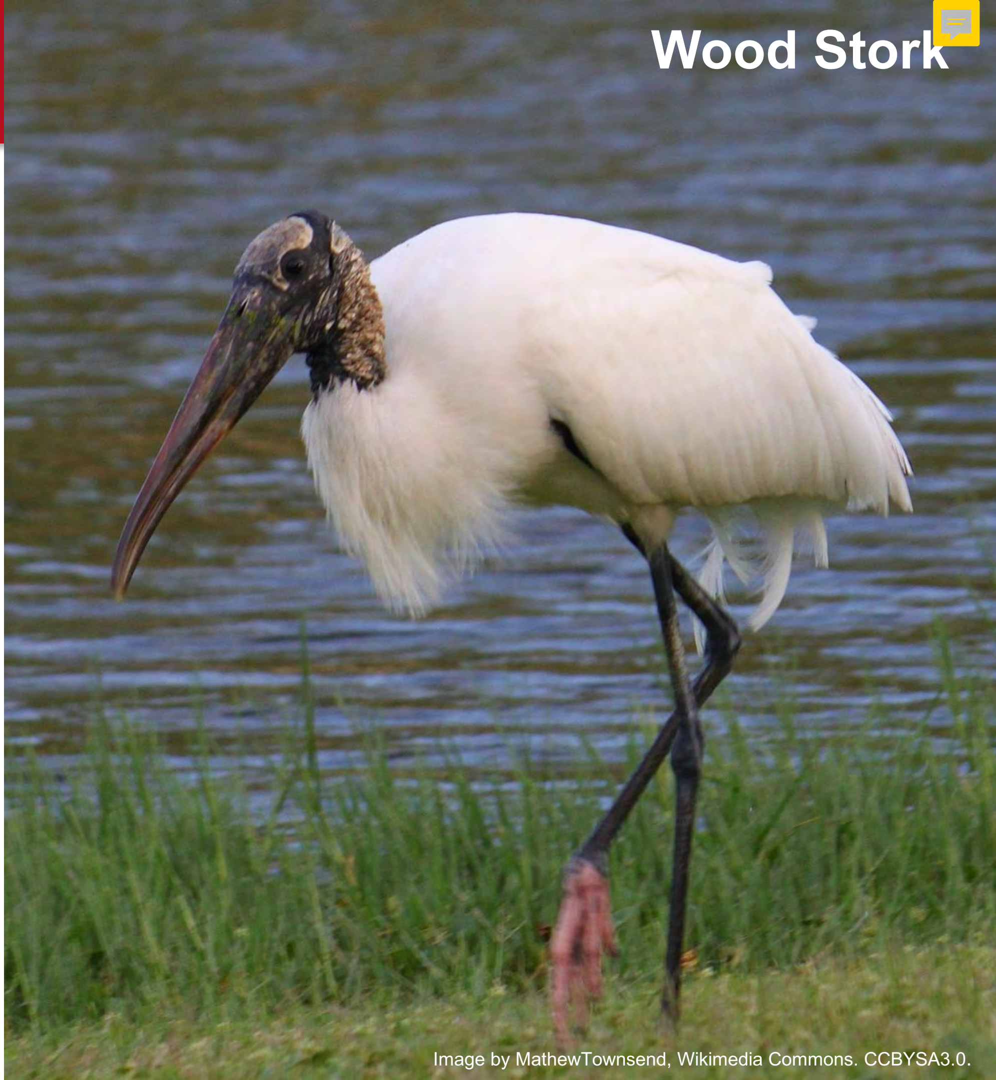
Typical traits:

- Fast growing
- Reproduce quickly
- Tolerate a wide range of environmental conditions
- Survive on wide range of food sources
- Can thrive in areas occupied by humans

Indicator Species = a species that is particularly vulnerable to ecosystem perturbations, and that, when we monitor them, can give us advance warning of a problem

Definition adapted from Environmental Science for a Changing World

Indicator species can signal both a healthy or unhealthy environment. They can show information about pollution, nutrient levels, salinity, temperature or food availability and more.



Objective 2: Describe possible relationships and interactions between species in a community.

Species Interactions

Communities are defined as a group of interacting species occupying the same location. A community is living organisms bound together by their interactions and relationships between different species. We can better understand communities by examining how species interact with one another and the resulting effects that occur for each species. Changes within one species can result in cascading effects on other species within a community.

We can describe and define interactions based on **positive, neutral, or negative effects** that the interactions have on the species involved.

Symbiosis = Biological or ecological interactions between two species that live in close physical association

Typically, long-term interactions.

There are three forms that this relationship can take:

- Mutualism
- Commensalism
- Parasitism

Mutualism = A symbiotic interaction between two species where both species benefit

Definition adapted from Environmental Science for a Changing World

Examples of mutualism:

- Bees and flowering plants
- Humans and digestive bacteria
- Oxpeckers and zebras or rhinos

Honeybee and Flowering Plant

Commensalism = An association between individuals of two species in which one benefits, but the other neither benefits nor is harmed

Examples of commensalism:

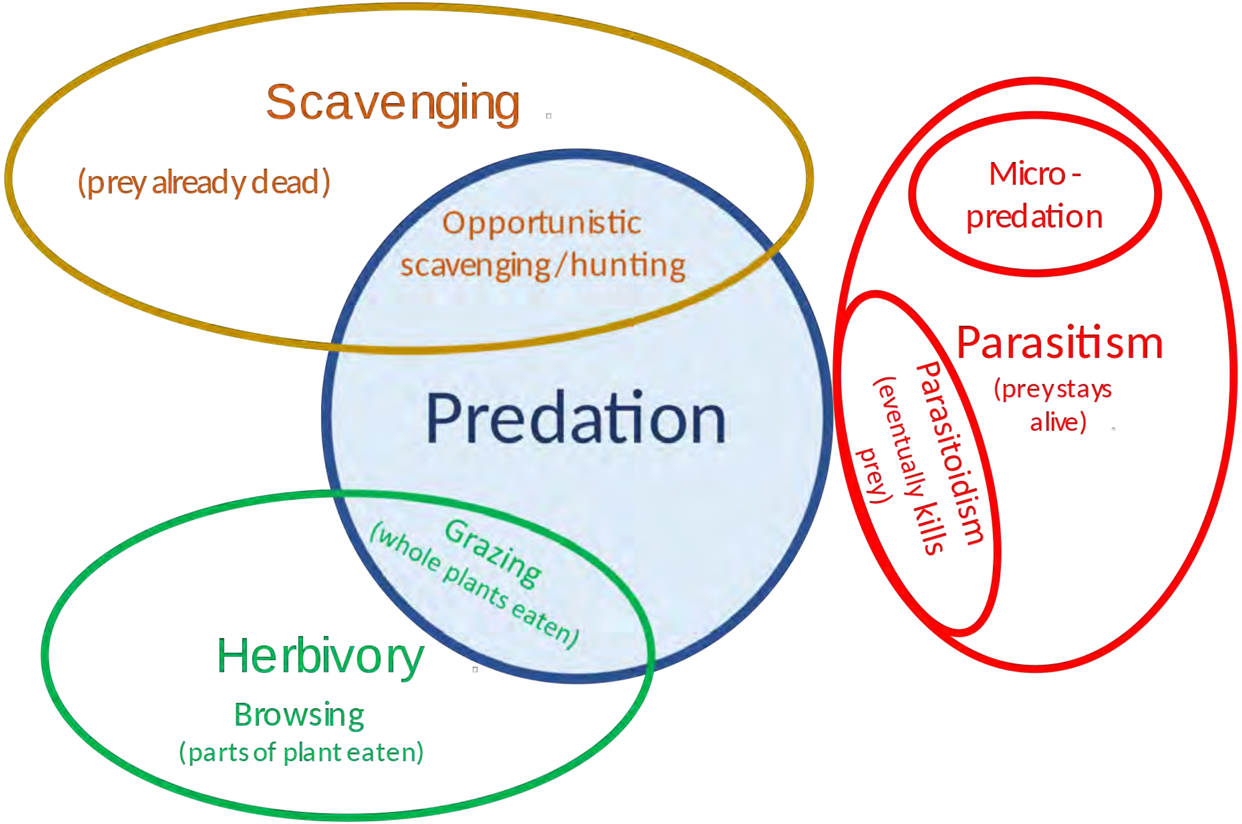
- Livestock and egrets
- Sharks and suckerfish
- Milkweed and monarch butterfly

Parasitism = An association between individuals of two species in which one benefits, and the other is harmed

Examples of parasitism:

- Fleas and ticks on pets
- Viruses and bacteria
- Cuckoo birds laying eggs in other birds' nests
- Mosquitoes and mammals

Predation = A relationship between individuals of two species in which one organism, the predator, kills and consumes the other, the prey



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Predation Defense

Both predators and prey are strongly influenced by natural selection. Species have evolved numerous ways to evade predators.

Defense mechanisms can be classified as:

- Mechanical
- Chemical
- Physical
- Behavioral

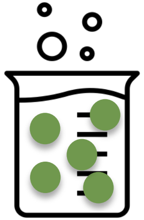
Competition = A relationship between individuals of two species in which both parties are harmed

Competition can be direct or indirect.

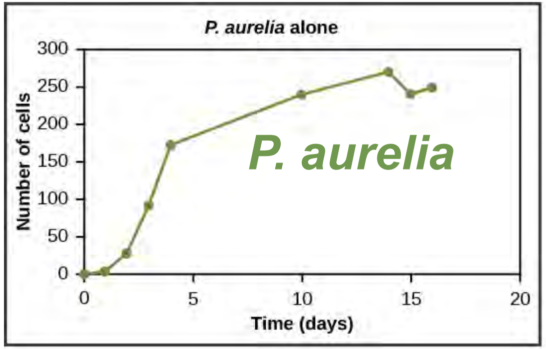
Examples of competition:

- Plant species competing for temperature, light, humidity, growing space, etc.
- Animal species competing for water, food, shelter, prospective mates, etc.

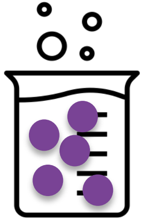
Competitive Exclusion Principle = states that two species are unable to coexist within the same exact ecological niche



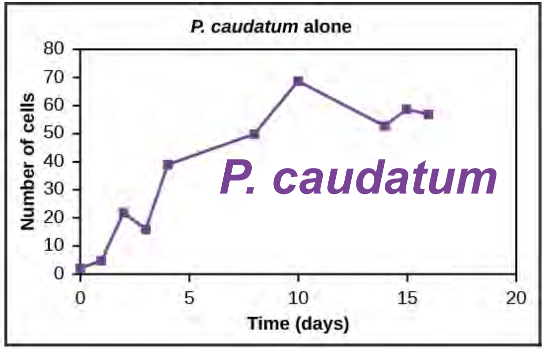
One species of protozoa growing by itself



A



A different species of protozoa growing by itself



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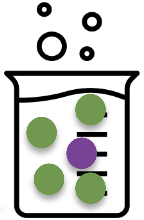
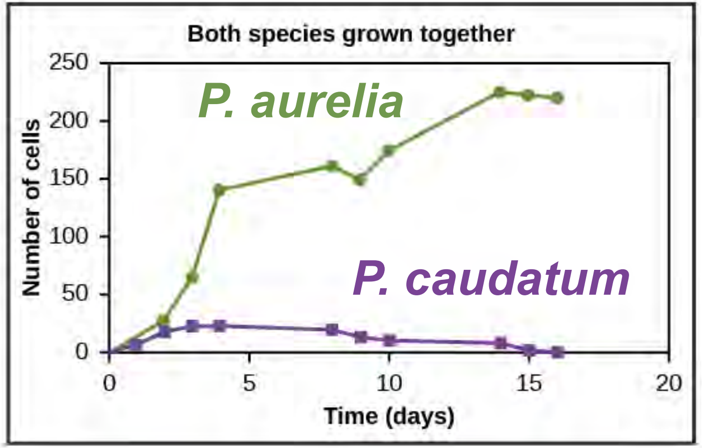


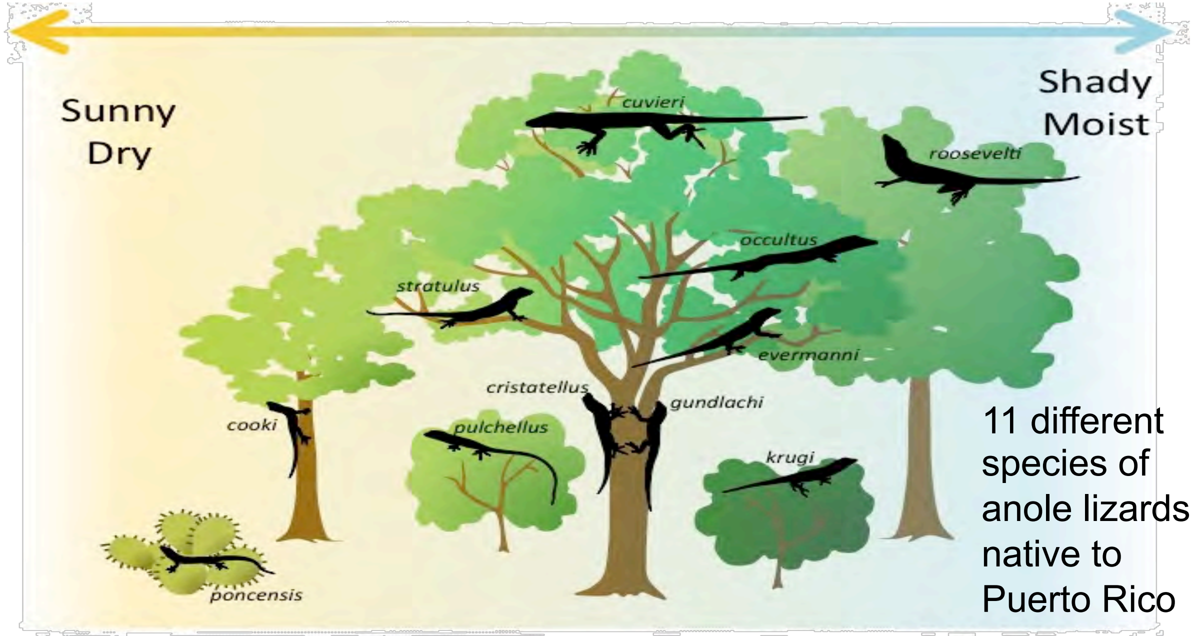
Mix both species and grow together



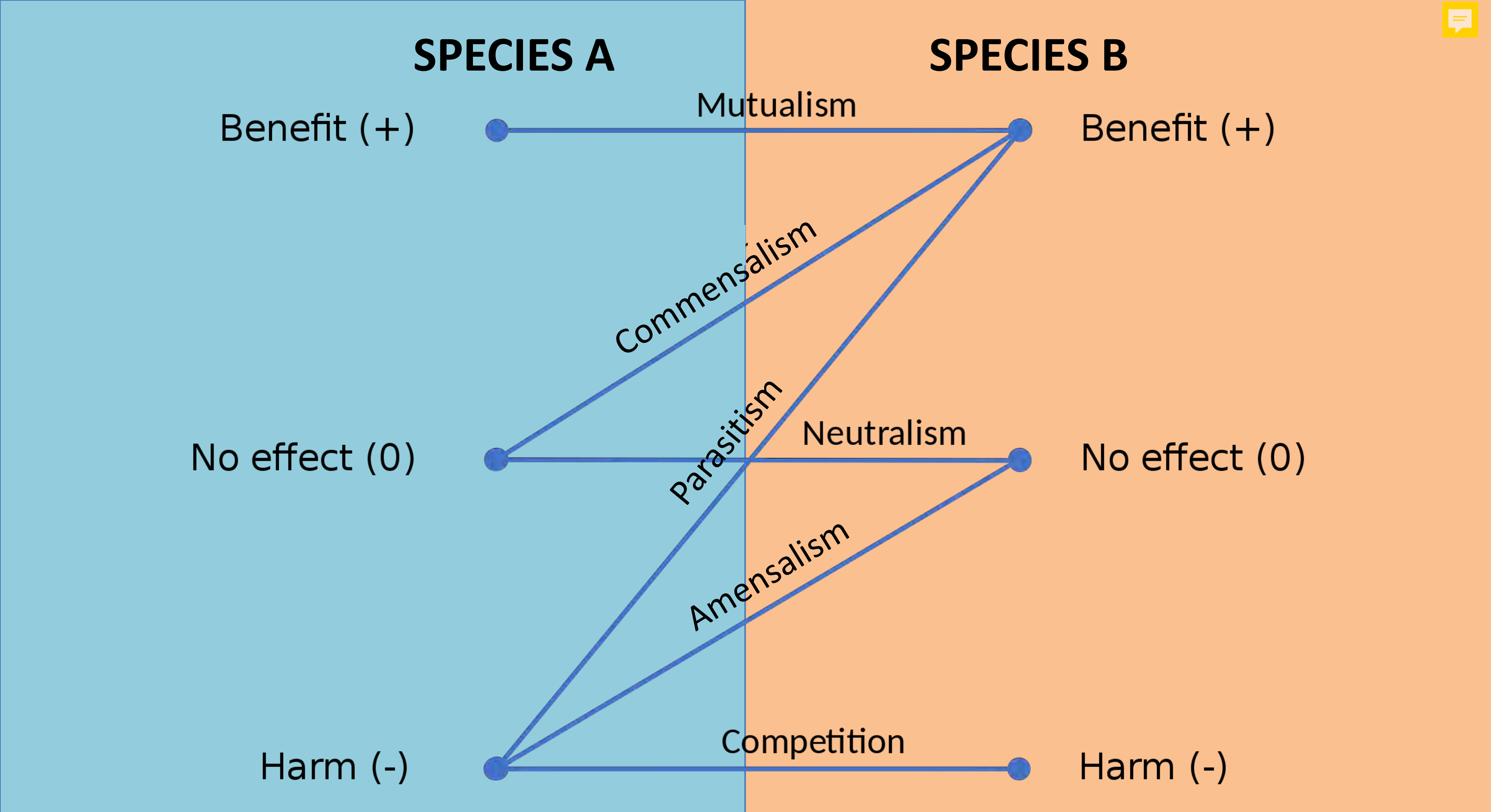
C

Resource Partitioning = to coexist and avoid competition, different species utilize different parts of a resource that is limited, often using the resource in different ways

Communities allocate resources to reduce competition. In doing so, this allows more species to co-exist with one another with an ecosystem. This increases the ability of the entire community to capture energy and matter, thus benefiting all species living within the ecosystem.



11 different species of anole lizards native to Puerto Rico


SPECIES A
SPECIES B
Mutualism
Benefit (+)
Benefit (+)
Commensalism
Parasitism
Neutralism
No effect (0)
No effect (0)
Amensalism
Competition
Harm (-)
Harm (-)

Objective 3: Conceptualize how energy and matter flow through, support, and are transferred within an ecosystem.

Ecosystems all share two common traits:

1. Energy always flows in one direction
2. Matter (chemical elements) are recycled and reused

Thermodynamics = the study of energy transfer and energy transformation

1st Law of Thermodynamics: Energy cannot be created or destroyed, only transferred or transformed to a different form.

2nd Law of Thermodynamics: When energy is transferred or transformed through an ecosystem, part of that energy is lost as heat, which cannot be used by living organisms to grow, survive or reproduce.

Biomass = total mass of living organisms

Primary producers convert the sun's energy into biomass (photosynthesis). This biomass is then transferred up the food web to different trophic levels. The efficiency of energy transfer from trophic level to trophic level is important to understanding the behavior of the organisms within the community. Modeling this energy flow in a food web is done using a trophic pyramid and provides vital information regarding the structure of an ecosystem, its energy and biomass.

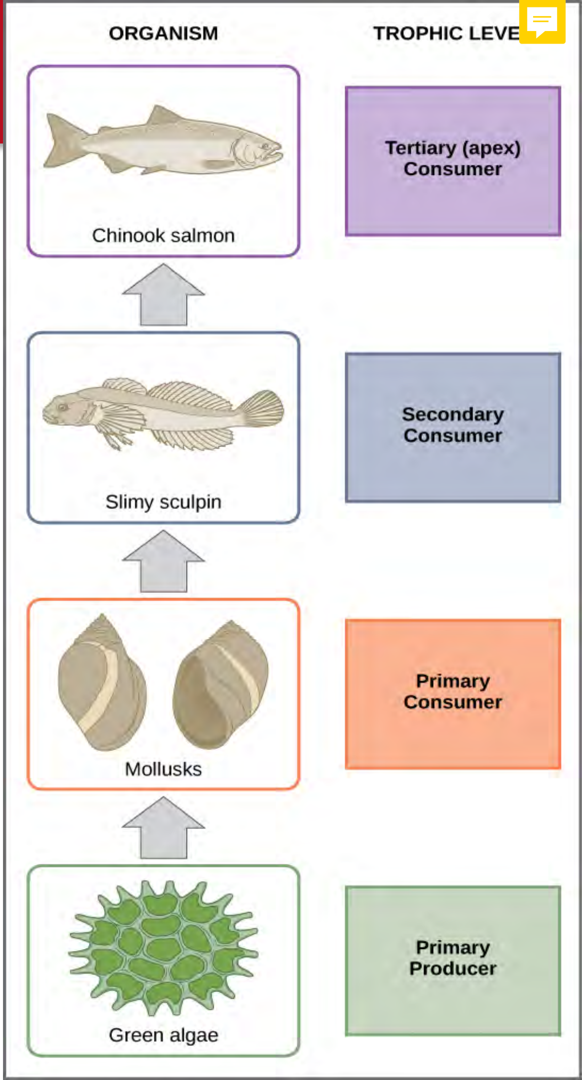
An ecosystem must maintain and recycle biomass in order to thrive. The biomass depends on the connectivity of the food chain or food web. If there are weak links or threats in the food chain or food web, the biomass may decline.

Food Chain = linear transfers of energy and matter from organism to organism

There are many players involved in a food chain:

- Primary producers (e.g., photosynthetic organisms)
- Primary consumers (e.g., herbivores)
- Higher-level consumers (e.g. carnivores)

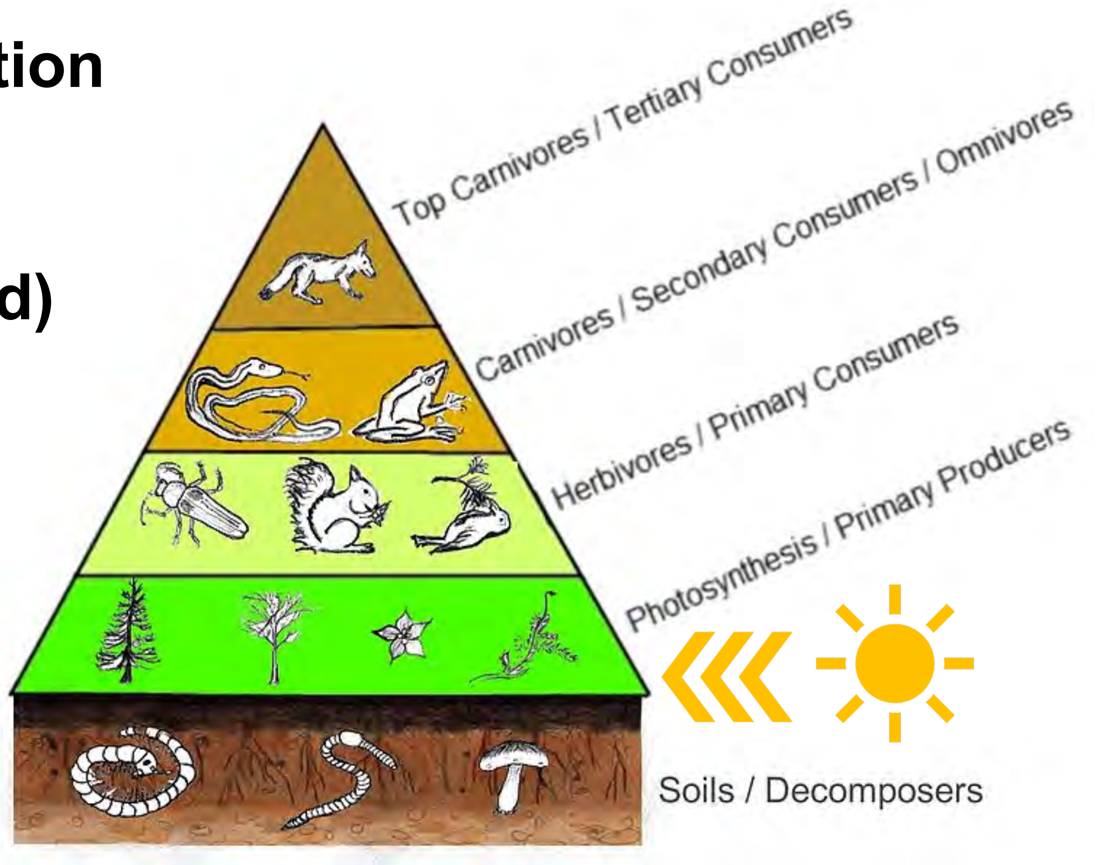
A food chain is a single linear pathway for the transfer of energy. Starting with primary producer and ending with apex predator.



Trophic Level = the position an organism occupies within an ecological pyramid (or food pyramid)

Depending on an organism's role in the community, it is assigned to a specific trophic level.

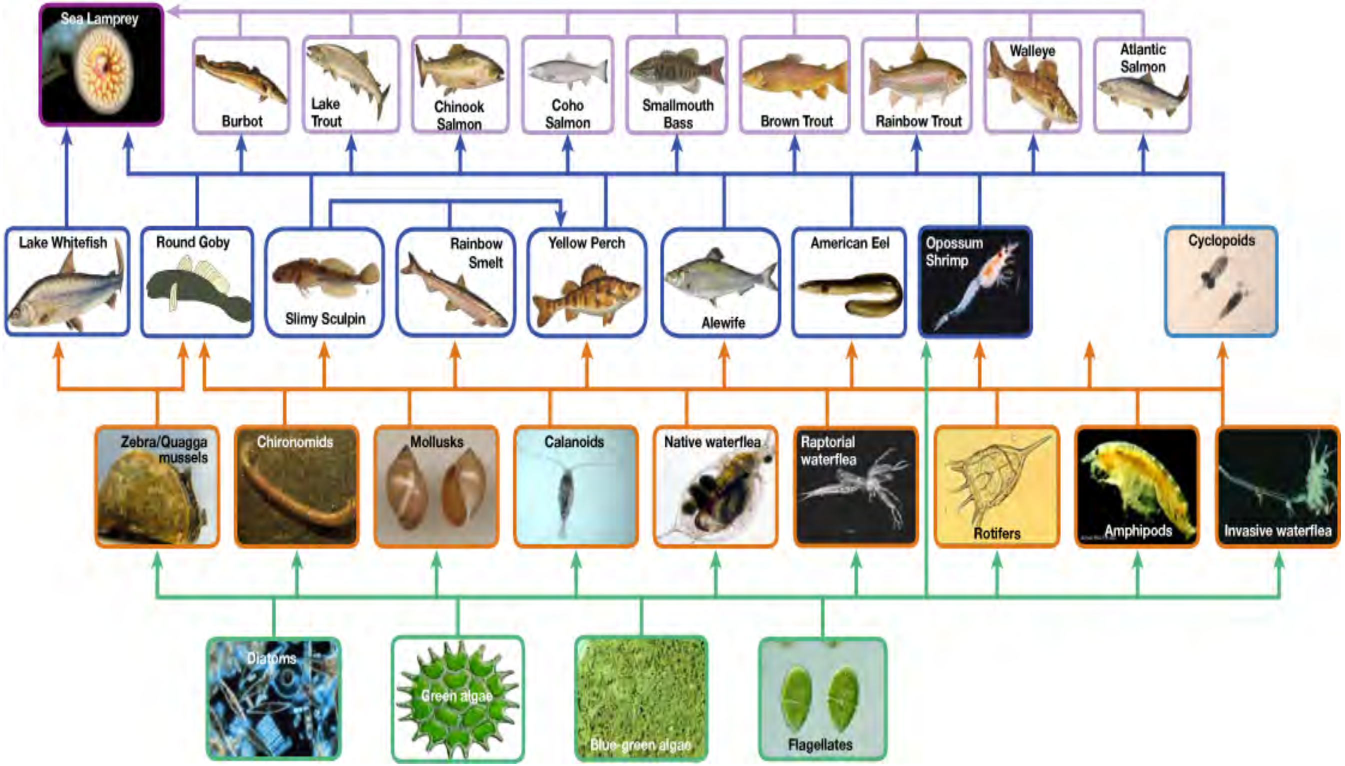
In this example, energy flow starts with photosynthetic organisms and ends with carnivores.



Food Web

Food webs show multiple pathways or matter and energy transfers and is non-linear.

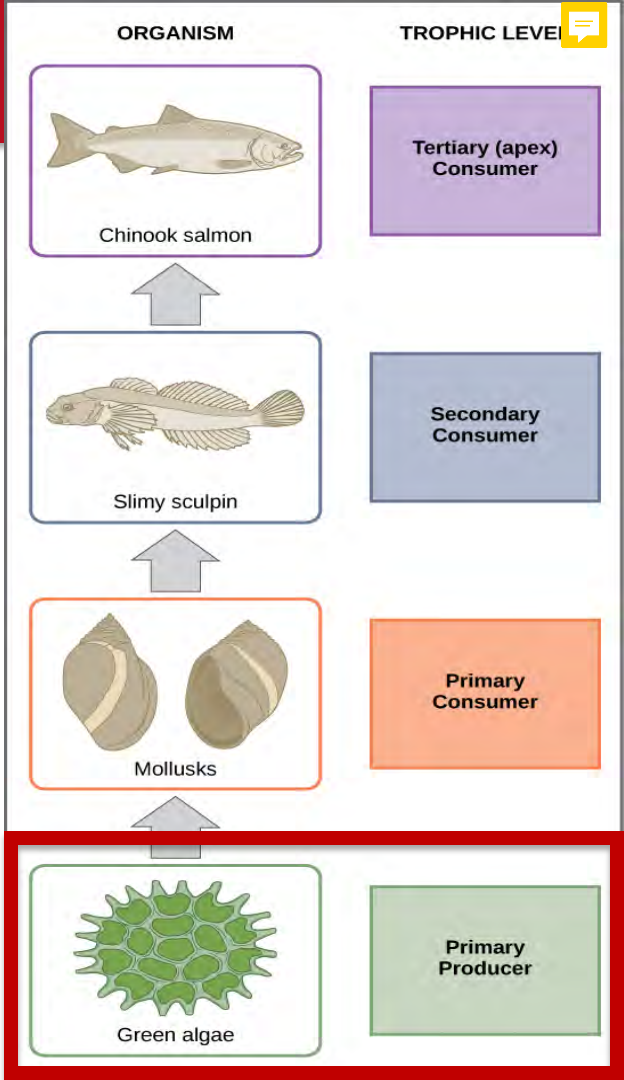
A food web is a holistic model which shows the interconnected relationships of the community.



Primary Producers

- Make up the first trophic level
- Also known as autotrophs, producers make their own food and do not rely on others for nutritional needs
- Plants, algae and phytoplankton are the most familiar type of primary producers and use photosynthesis to produce energy for growth and reproduction that is then passed up the food chain as consumers eat them

Energy Flow



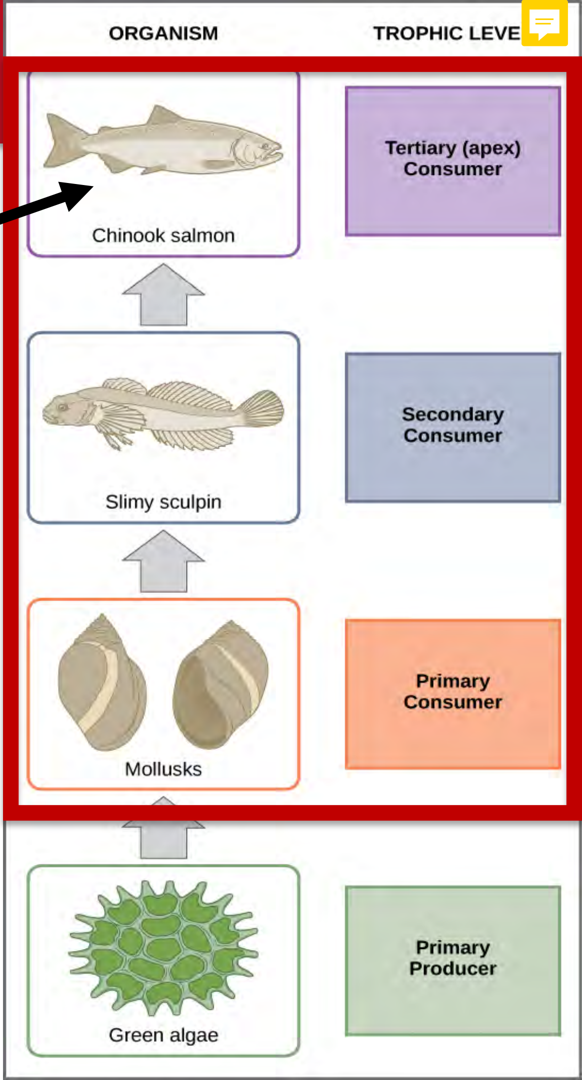
Consumers

apex predator

- Trophic levels above the producers are made up of consumers
- Can be primary, secondary, and so on.

Primary consumers are herbivores that directly consumer the producers.

Consumers after this second trophic level can be herbivores, omnivores, or carnivores. The consumer that is at the top of the food chain is known as the **apex predator**.



Decomposers and Detritivores

Decomposers and detritivores are an essential part of the food chain that is often forgotten. These organisms feed on dead animal and plant remains and break down this material, recycling it into nutrients like carbon and nitrogen that primary producers, like plants, then use to grow.

Examples:

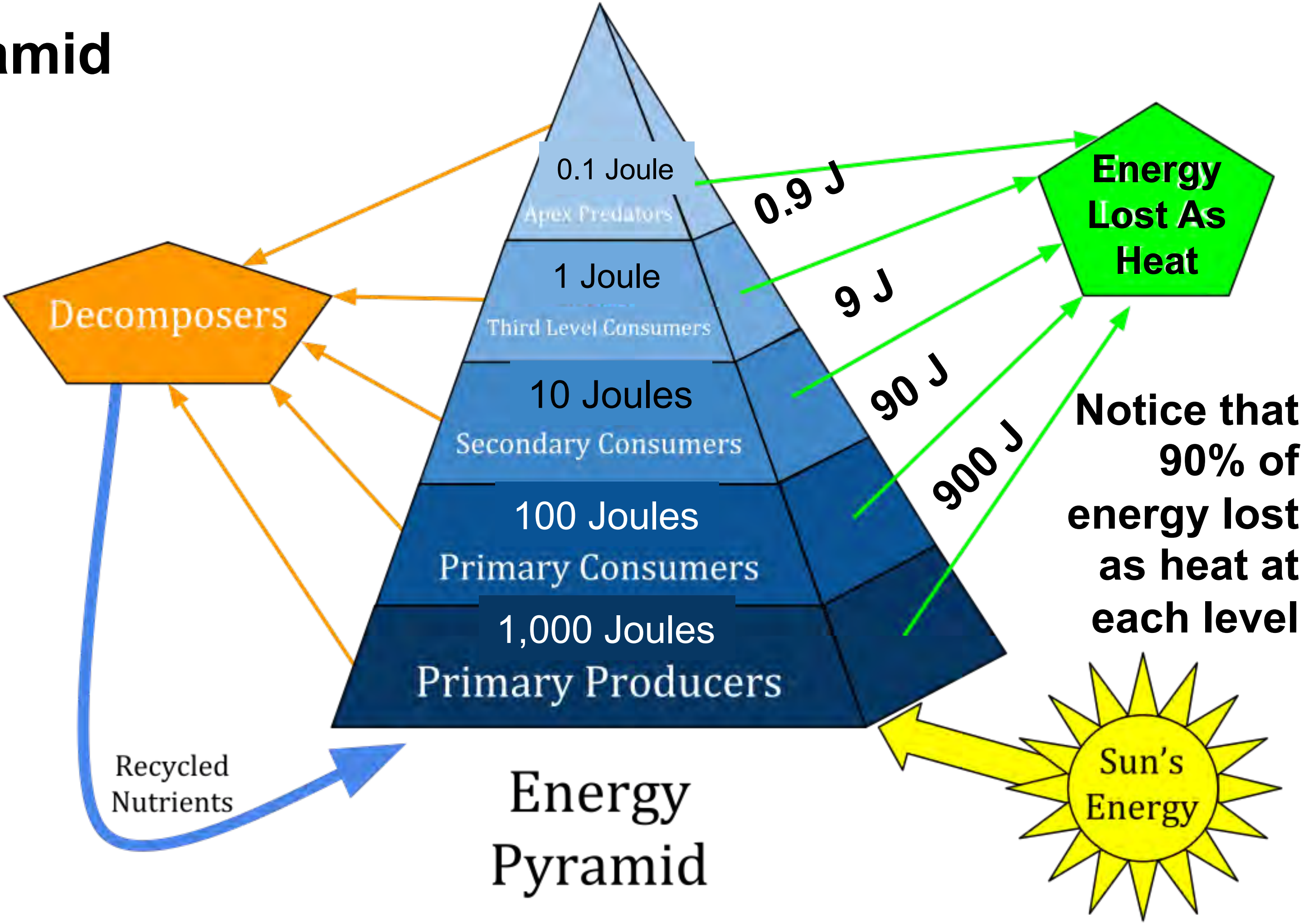
- Scavengers such as vultures
- Worms, slugs, millipedes
- Fungi and bacteria

Image by JJ Harrison, Wikimedia Commons. CCBYSA3.0.

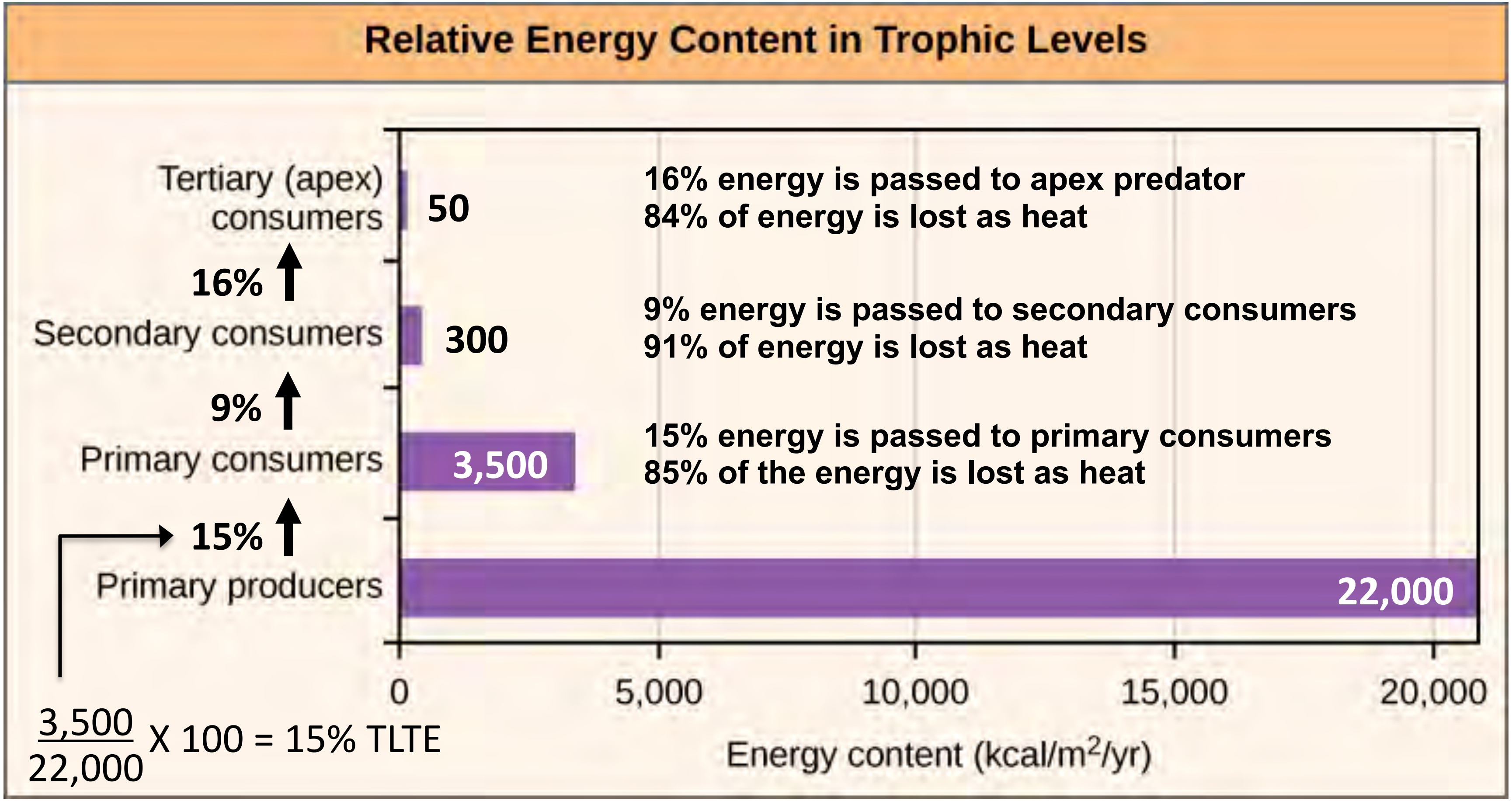
Trophic Pyramid

Energy flows in one direction (up in this example)

Matter (e.g., carbon, nitrogen) is recycled by decomposers



Notice that 90% of energy lost as heat at each level


Relative Energy Content in Trophic Levels
Tertiary (apex) consumers
50
16%
Secondary consumers
300
9%
Primary consumers
3,500
15%
Primary producers
22,000
16% energy is passed to apex predator
84% of energy is lost as heat
9% energy is passed to secondary consumers
91% of energy is lost as heat
15% energy is passed to primary consumers
85% of the energy is lost as heat
0
5,000
10,000
15,000
20,000
Energy content (kcal/m2/yr)
3,500
22,000
X 100 = 15% TLTE

Ecological Efficiency

As the 2nd Law of Thermodynamics shows, energy is always lost when it is transferred from one trophic level to the next. As energy is transferred from primary producers to herbivores to carnivores, energy is lost as heat with each step up the pyramid.

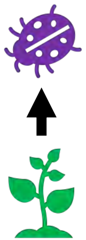
This transfer of energy through the trophic pyramid is NOT very efficient. Typical efficiencies are 2-40%. This is known as the **ecological efficiency.** In the previous slides we estimated these values to be 9-16% for each step up the trophic pyramid.

If we want to calculate the energy transfer efficiency between two trophic levels, we can use the formula for **trophic level transfer efficiency (TLTE).**

$$\mathrm{TLTE} = \frac{\text{production at present trophic level}}{\text{production at previous trophic level}} \times 100$$

Example:

$$\mathrm{TLTF} = \frac{9 \text{ Joules}}{112 \text{ Joules}} \times 100\% = 8\%$$



9 Joules

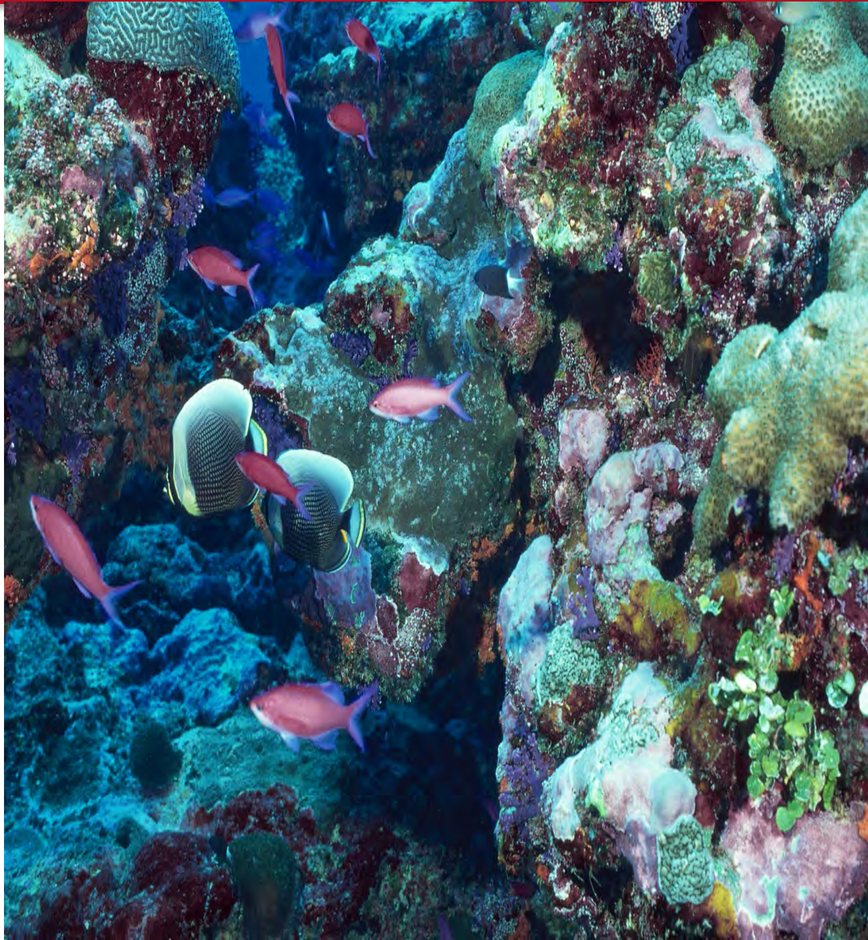
112 Joules

Objective 4: Identify defining characteristics of community structure and dynamics.

Characteristics of Communities

Communities can be characterized by their **structure** and **dynamics.**

It is important to recognize both structure and dynamics when managing communities and understanding potential effects.



Community Structure

Ecologists measure the composition of a community (**community structure**) by calculating **species richness** and **species evenness** and understanding how all the species relate and interact with one another (e.g., predator-prey, parasite-host). Community structure is affected by both abiotic and biotic factors.

Factors that impact community structure:

- Climate (e.g., precipitation, temperature)
- Geography (e.g., coastal, mountains)
- Environmental characteristics (e.g., heterogeneous, homogenous)
- Interactions between species (e.g., mutualism, predation)

Community Structure

Community structures changes over time. Communities must adapt through evolution to environmental and anthropogenic changes or face extinction.

When more ecological diversity exists within a community, it creates the opportunity for more niches to exist and more ways for energy to be exchanged. These factors increase a community's **resilience** (able to adapt to change).

There are two valuable measures that ecologists often use to measure the **ecological diversity** (also referred to as species diversity) in a community:

1. **species richness** (total number of different species)
2. **species evenness** (how close in number each species is)

Species Richness = total number of different species in a community

Species richness can be calculated simply by recording the number of different species in an area (e.g., red fox, gray wolf, grizzly bear, black bear, willow tree, honeybee, blueberry).

Ecosystems near the equator tend to experience the highest species richness. Ecosystems nearest the poles tend to experience the lowest species richness.

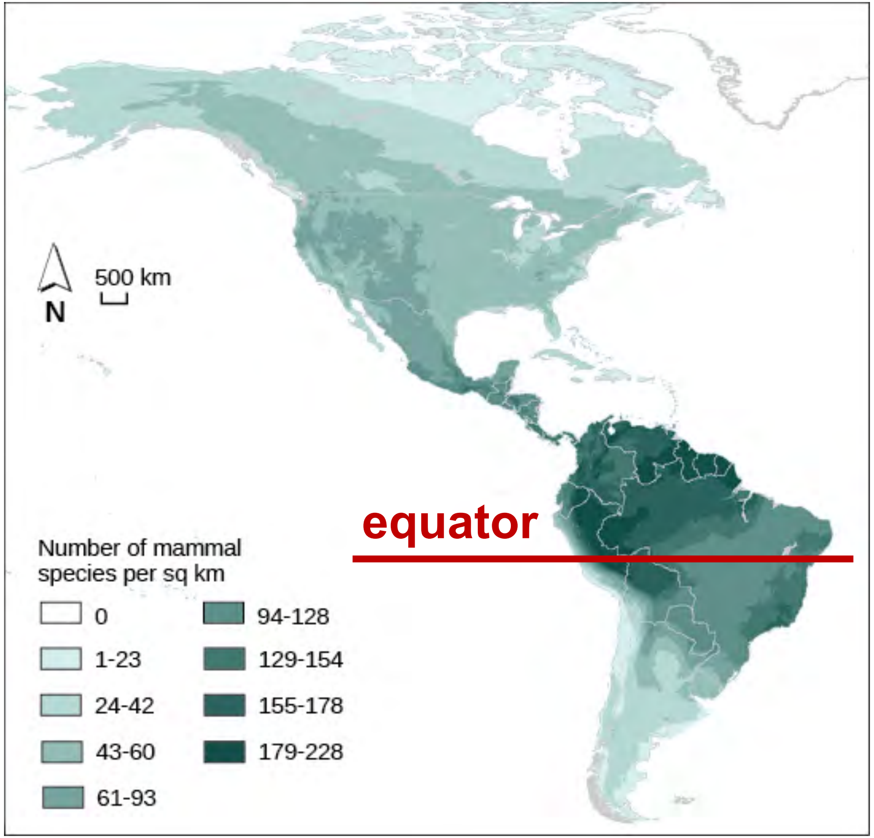


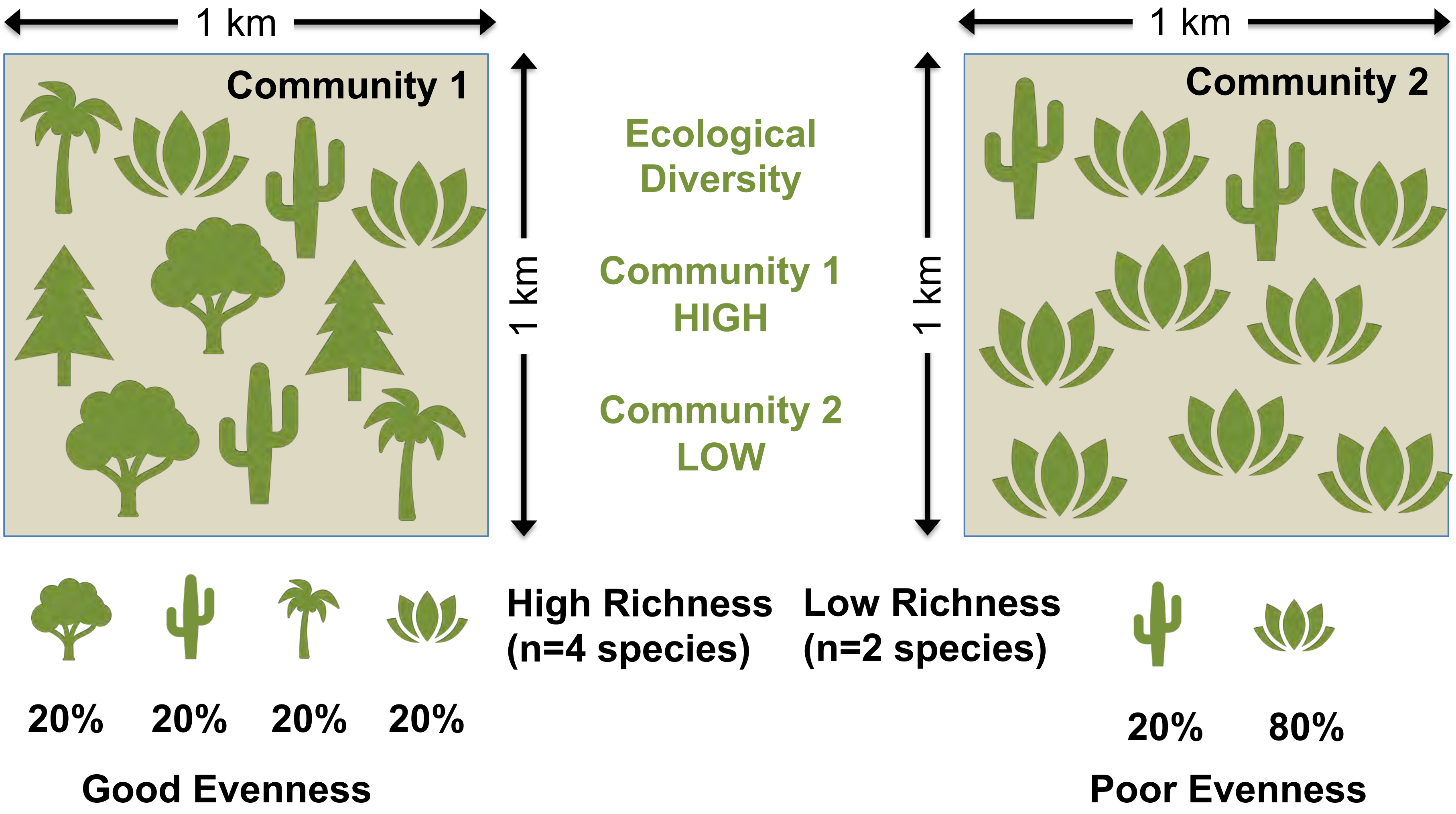
Image by NASA, CIESIN, Columbia.

Species Evenness = relative abundance of each species in a community

Typically, there are fewer individual organisms at higher trophic levels (e.g., gray wolves) and more individual organisms at lower tropic levels (e.g., grass).

Populations (e.g., gray wolves, grizzly bears) within the same trophic level (e.g., apex predator) should have similar numbers of individual organisms leading to a higher evenness (e.g., 10 wolves, 10 bears).

Uneven communities with less abundant species are more at-risk change and less able to respond to and withstand adverse situations.


1 km
Community 1
1 km
Ecological Diversity
Community 1 HIGH
Community 2 LOW
1 km
1 km
Community 2
20%
20%
20%
20%
Good Evenness
High Richness (n=4 species)
Low Richness (n=2 species)
20%
80%
Poor Evenness

Community Dynamics

Community dynamics are the changes to a community’s structure and composition over time.

Communities that contain a relatively constant number of species are in equilibrium. This equilibrium is dynamic and varies with species types, numbers and their relationships with one another, which may change over time.

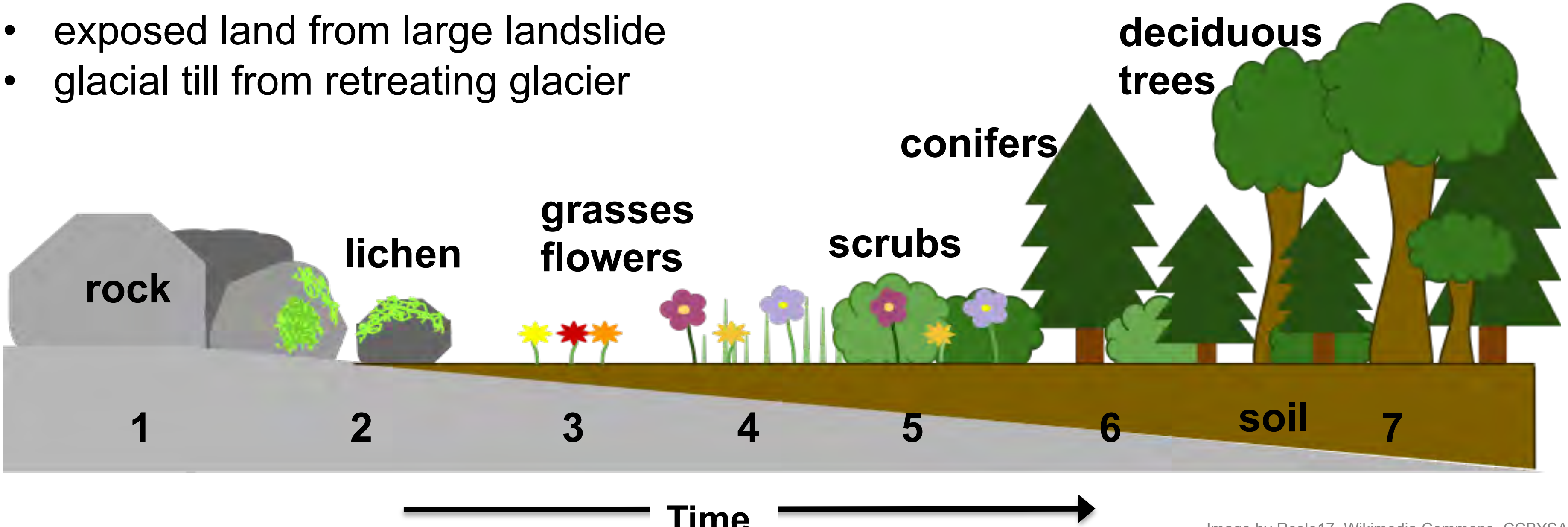
A disturbance will affect a community’s ability to maintain an equilibrium state. A healthy community will be better able to withstand and respond to disturbances.

Ecological Succession = the process of gradual change in the type and number of species of a community over time

Primary Succession

Primary succession occurs in **new habitats** that have not yet been colonized by living organisms and are not affected by pre-existing communities. Examples:

- lava flow from volcano
- exposed land from large landslide
- glacial till from retreating glacier



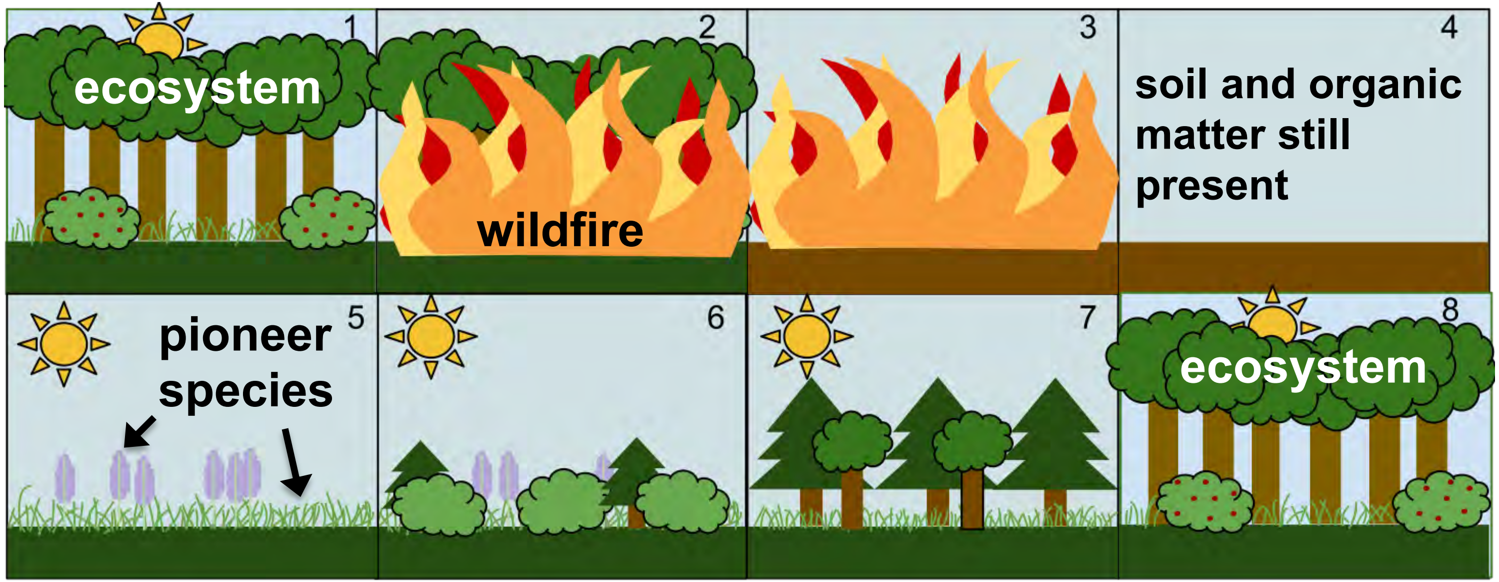
Pioneer species = the first species to colonize a barren ecosystem

Typical traits of a pioneer species:

- Withstand harsh conditions
- Adapted to reproduce by various means
- May have physical adaptations such as long roots, ability to grow on rocks, etc.
- Survive prolonged dormancy

Secondary Succession

Secondary succession occurs more quickly (years to decades) than primary success (centuries to millions of years) and is started because of a disturbance event that occurs in an existing ecosystem. For example, a fire, avalanche, flood.



Environmental Disturbance

A disturbance is an event (natural or anthropogenic) that alters an ecosystem. Events vary in frequency and impact. Disturbances can dramatically alter an ecosystem.

Examples:

- Fires
- Volcanic eruptions
- Earthquakes
- Clearcutting forest
- Invasive species
- Mountaintop removal
- Climate change

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Climax community = An ecological community in the final stage of succession in which the organisms remain stable and exist in balance with the ecosystem

This often takes thousands to millions of years.

Habitat fragmentation = the discontinuance of a natural habitat

Fragmentation is often caused by humans. This alteration can have severe impacts on a community's biodiversity.

Causes of fragmentation include:

- Climate change
- Agriculture
- Urbanization

Edge Effects = the changes in community structure that occur at the boundary between two habitats (ecotone)

This describes the greater biodiversity that can be found when two different ecosystems overlap, as species of both ecosystems can occupy the area, as well as unique species that are adapted to the edges.

Ecotone = a zone of transition between two communities or habitats

These boundaries transitions can be very sharp and defined or gradual and not well defined.

An ecotone may be formed naturally, or it may be created through human intervention.

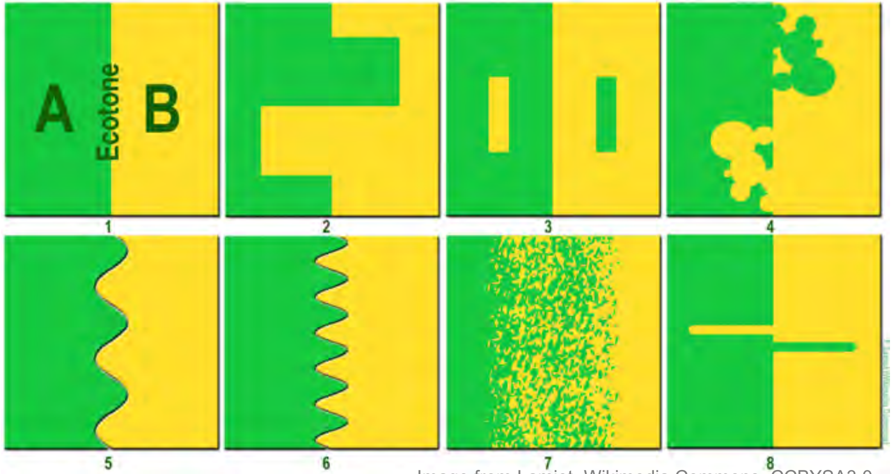

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Image from Gunter Klug, Wikimedia Commons, CCBYSA2.5.

Restoration Ecology = the study of repairing damaged ecosystems by human intervention

Restoration ecologists work to improve ecosystems that have been damaged due to disturbances. This work involves repopulating and reestablishing both plants and animals in the communities that have been damage.

Examples of restoration actions:

- Revegetation
- Habitat enhancement
- Remediation

Restoration Ecology

Restoration projects take place in a variety of ecosystems. We often use restoration techniques to improve land previously damaged by human development or resource extraction.

The restoration of previous mines is called **mine reclamation.**

Steps involved in this process might include:

- Leveling or evening the land
- Adding new topsoil or appropriate substrate
- Re-seeding native vegetation
- Monitoring the area

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