Module 1:
What is Biodiversity?

Forestry Training Institute
Tubmanburg, Liberia

Key Topics

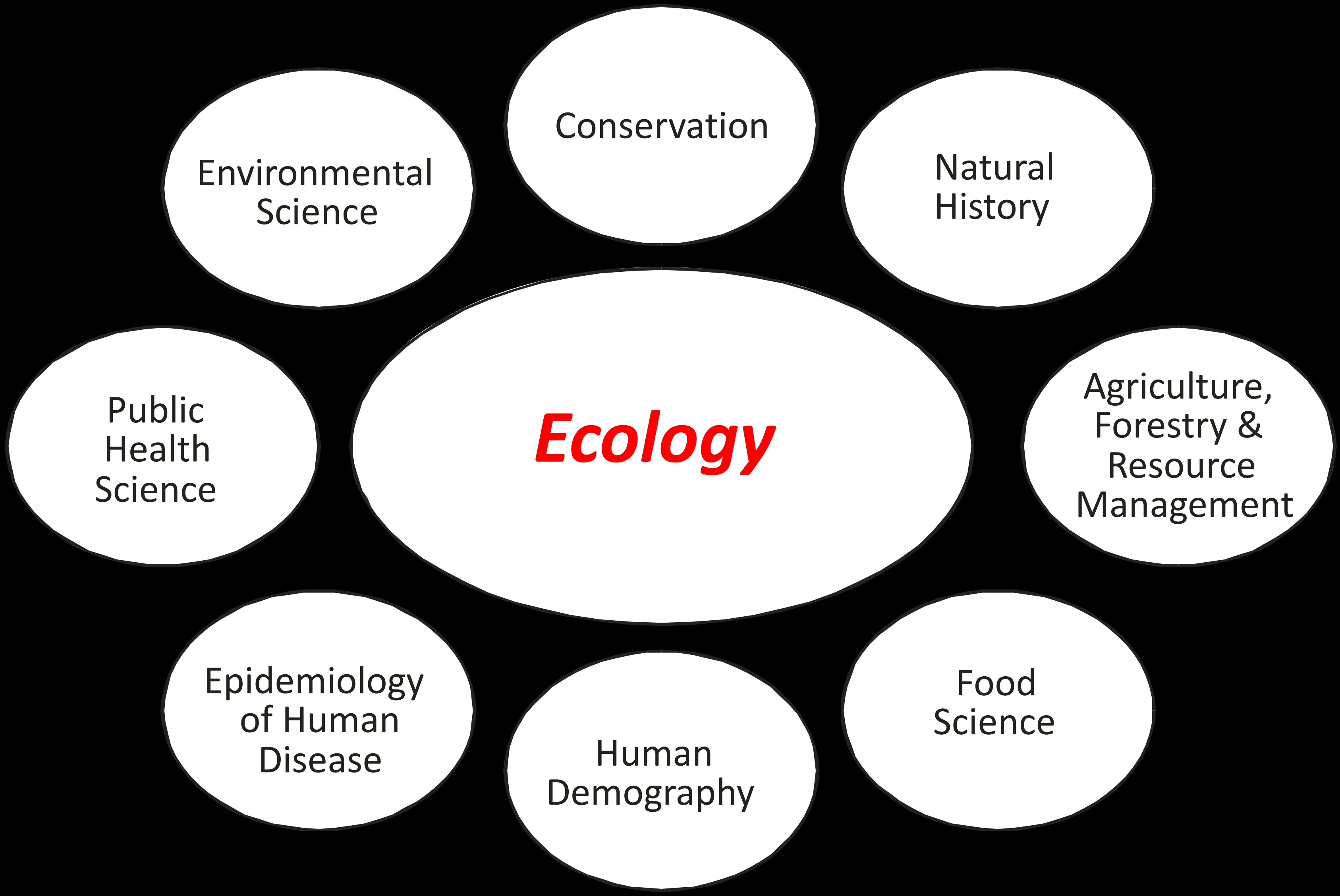
Fundamentals of Ecology

- Definitions and Applications
- Ecosystem Concepts
- Energy Flows and Materials Cycling
- Population Ecology
- Species interactions

Fundamentals of Ecology: Definitions

Ecology is the study of geographic distribution and abundance of organisms resulting from the interactions between organisms and their environment.

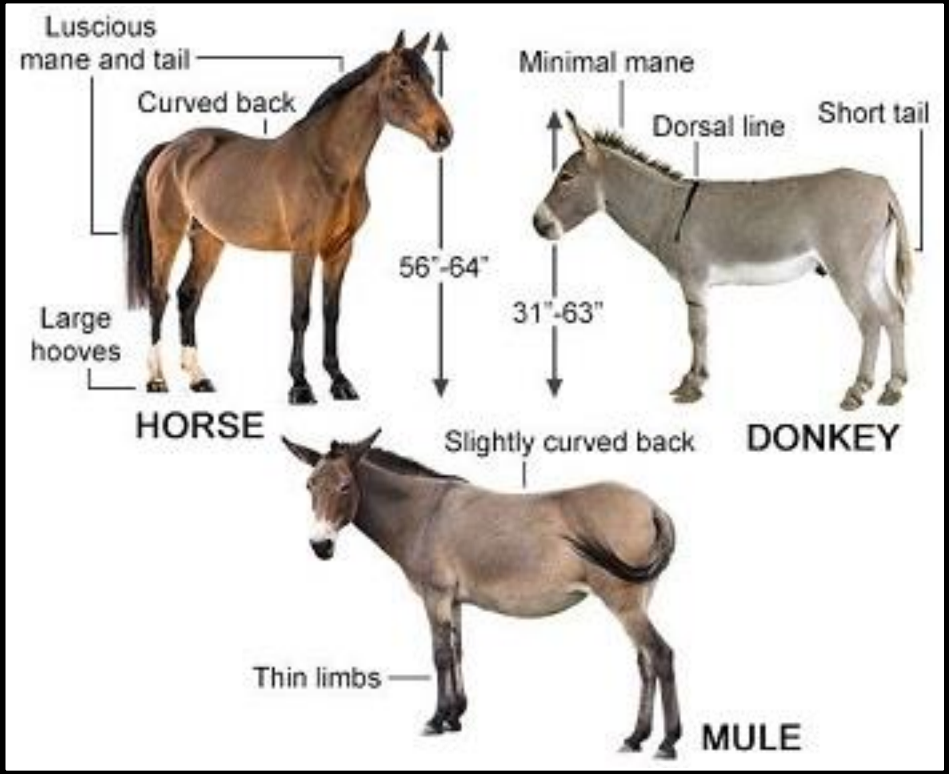
Fundamentals of Ecology: Applications



Fundamentals of Ecology: Ecosystem Concepts

A species is a collection of individuals that share particular physical or genetic traits.

Fundamentals of Ecology: Ecosystem Concepts

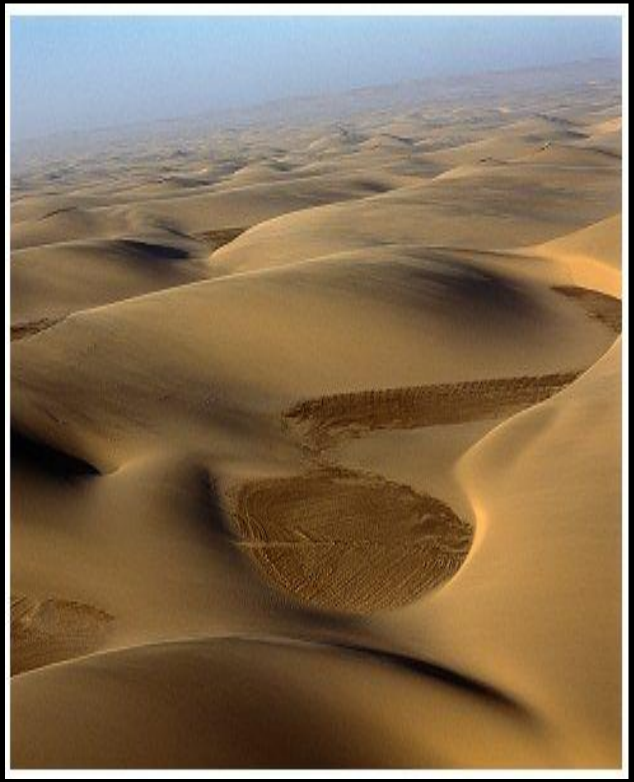


Life is so diverse that there is not a single definition of "species" that fits every organism. For organisms that reproduce sexually, a species is usually defined as a group of individuals that have the potential to produce fertile offspring.

- A classic example of this is the horse and the donkey, which are considered to be <u>different species</u>: even though they can breed with each other, they produce sterile offspring (mules).

Fundamentals of Ecology: Ecosystem Concepts

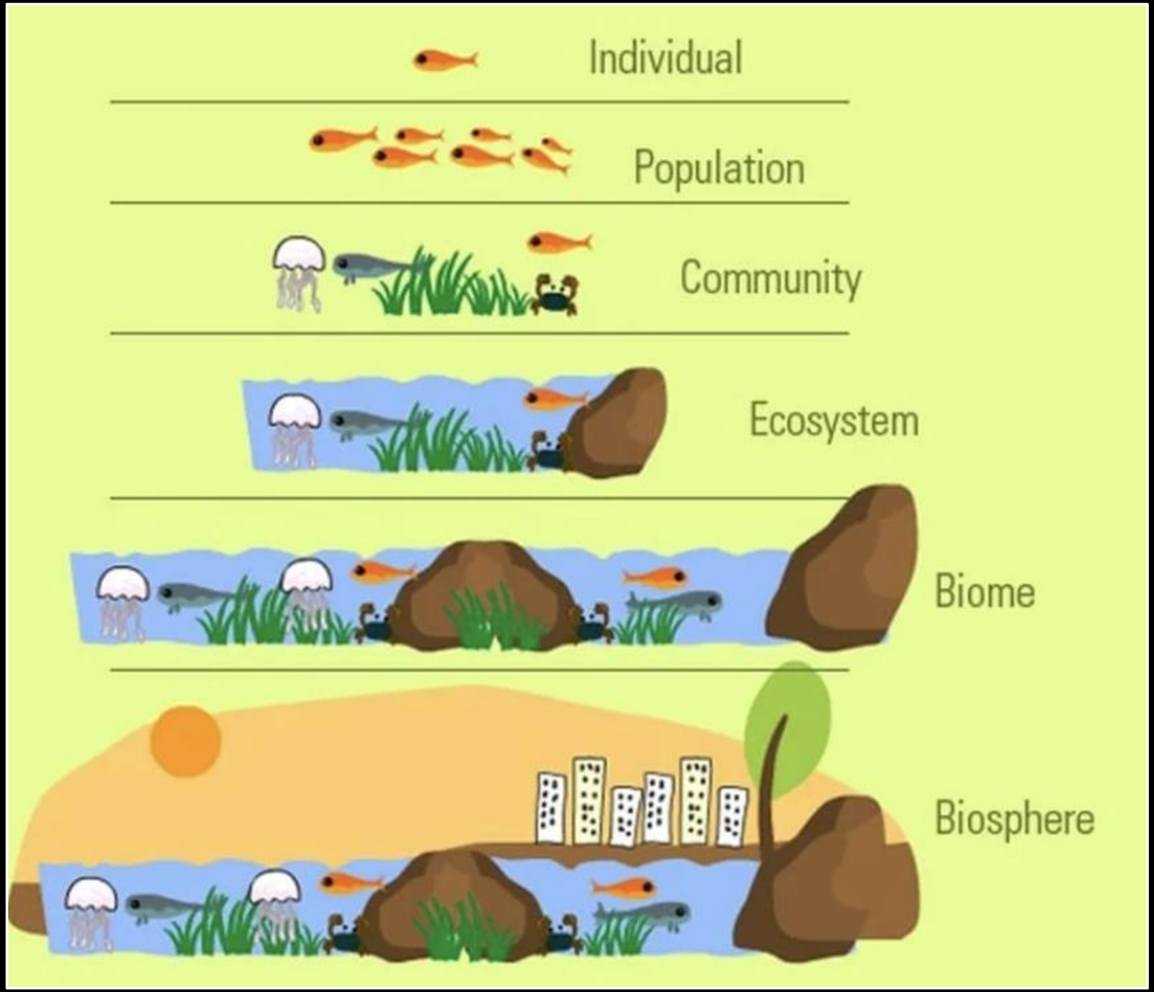
Habitats are the places or type of sites where an organism or a population naturally occurs.



Fundamentals of Ecology: Ecosystem Concepts

An ecosystem is the community of species present plus the physical environment with which they interact.

Fundamentals of Ecology: Ecosystem Concepts



An ecosystem consists of the biological community that occurs in a place, plus the physical and chemical factors that make up its non-living or abiotic environment.

- An ecosystem can exist at any scale, from a small tide pool up to the size of the entire biosphere.

Fundamentals of Ecology: Ecosystem Concepts

Ecosystems may be classified according to the dominant type of environment, or the dominant species, e.g., a mangrove swamp ecosystem.

Fundamentals of Ecology: Ecosystem Concepts

Broadly speaking, ecosystem diversity depends on the:

- physical characteristics of the environment (e.g., temperature, precipitation, energy flux, topography);
- diversity of species present;
- interactions between species (e.g., predation or parasitism, competition for available resources)
- The interactions between species and the environment.

Fundamentals of Ecology: Ecosystem Concepts

A landscape is a mosaic of diverse physical forms, vegetation types, and land uses in an area. Although there is no standard size of a landscape, they are usually in the hundreds or thousands of square kilometers.

Fundamentals of Ecology: Ecosystem Concepts

Species composition and population viability are often affected by the size, shape, and connectivity of ecosystems patches within the landscape. In order to ensure the survival of species that range widely across different ecosystems, biodiversity conservation efforts should be directed at whole landscapes.

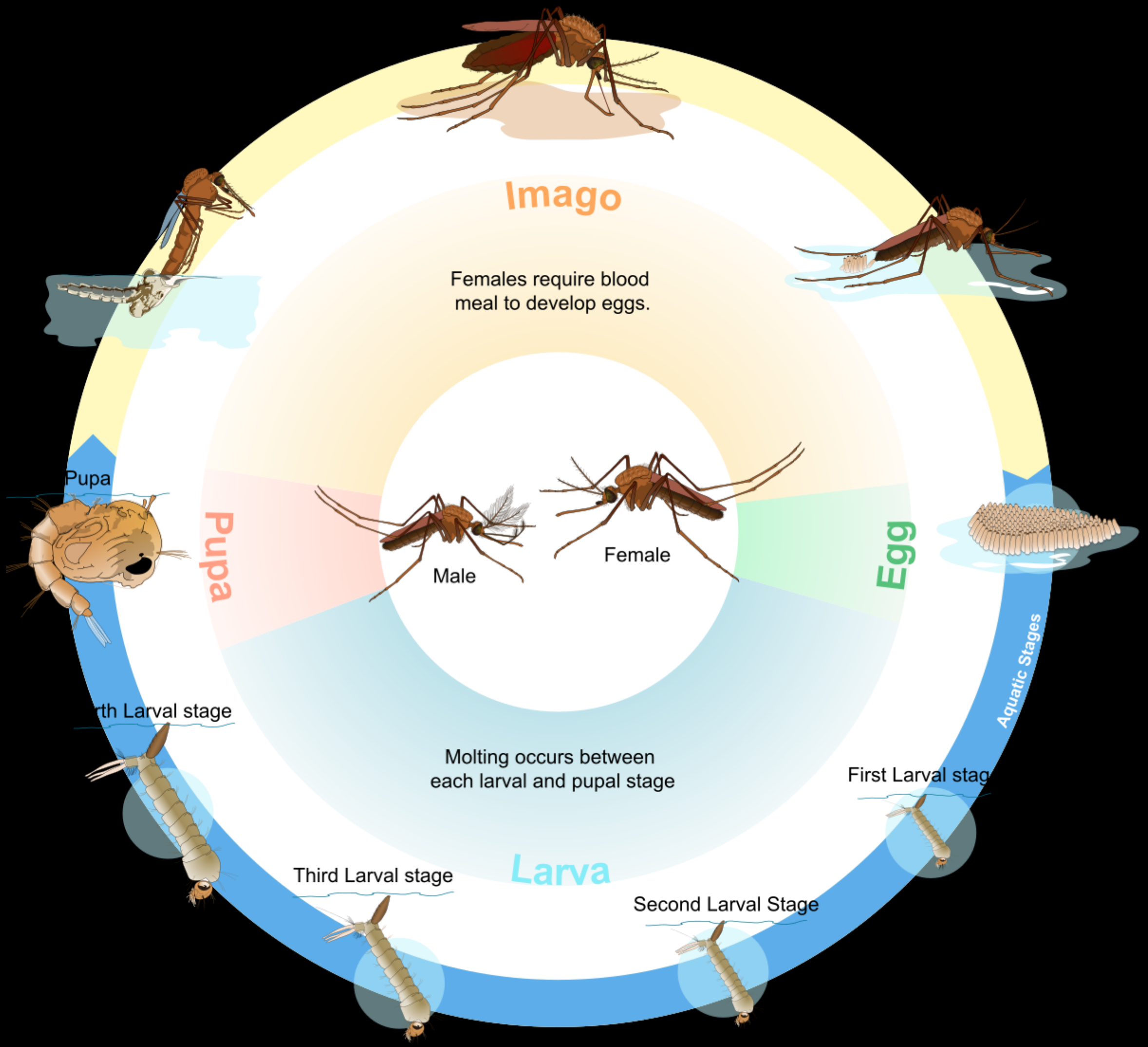
Fundamentals of Ecology: Ecosystem Concepts

Phenology is the study of biological life cycles throughout the year

- e.g., flowering and fruiting in plants, insect emergence, and the migratory and reproductive periods of mammals, birds, fish, and amphibians.

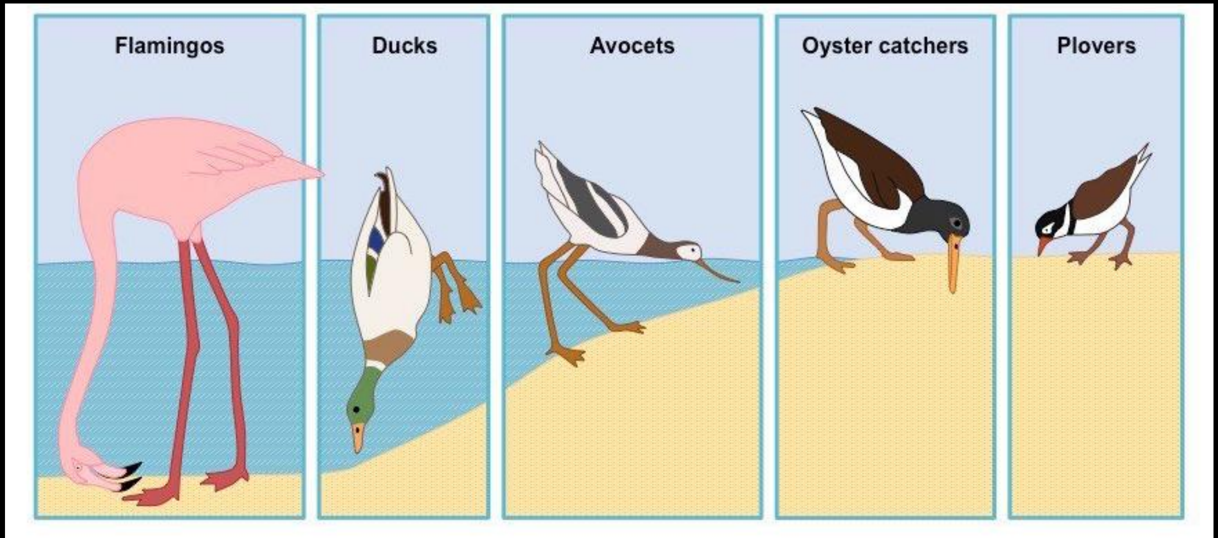
Fundamentals of Ecology: Ecosystem Concepts

Phenology: Plants and animals don't have calendars or watches. Instead, they take cues from the changing seasons. Seasonal changes in weather trigger organisms to enter new phases of their lives. Seasonal changes can include variations in day length, temperature, and precipitation.



Fundamentals of Ecology: Ecosystem Concepts

The ecological niche, a central concept in ecology, refers to a given species' particular way of obtaining shelter and energy within an ecosystem. Each plant or animal in an ecosystem fills an ecological niche, and different organisms compete for dominance in their preferred ecological niche.

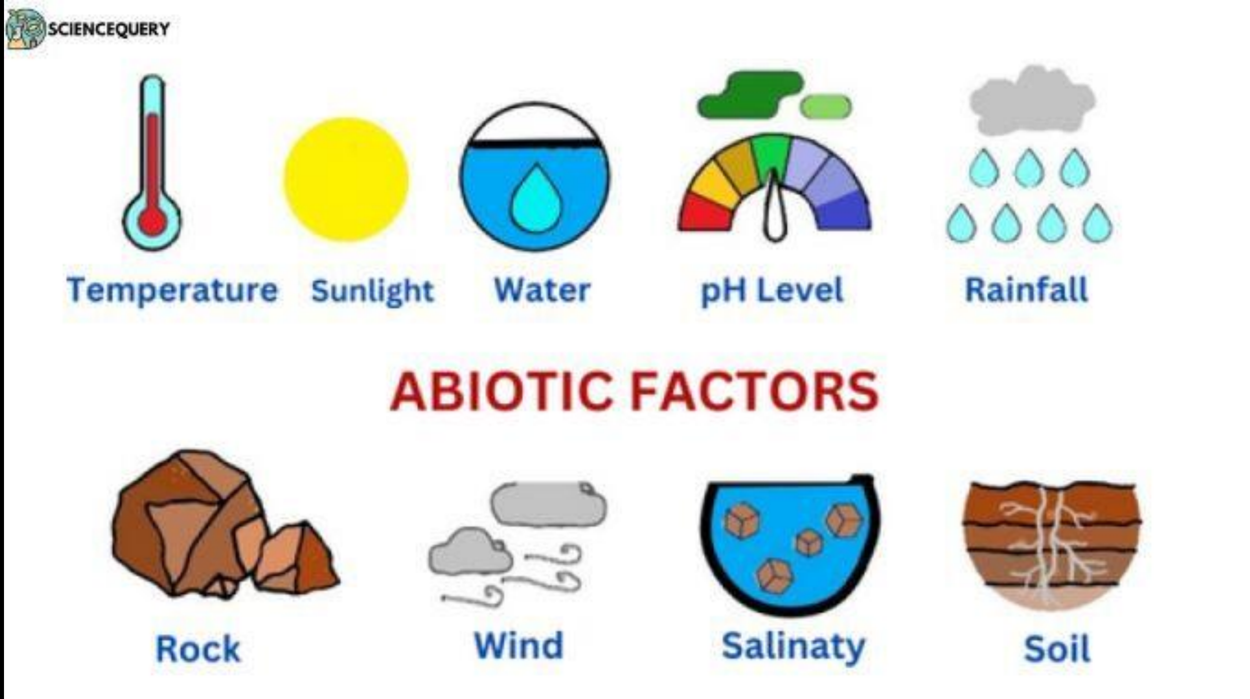


Fundamentals of Ecology: Ecosystem Concepts

In a forest ecosystem, there may be a niche that can be filled by one or more kinds of species, for example, pygmy hippos and mushrooms are both found in shaded wooded areas. Likewise, many kinds of fauna (e.g., fish) and flora (e.g., tree species) may share the same niche

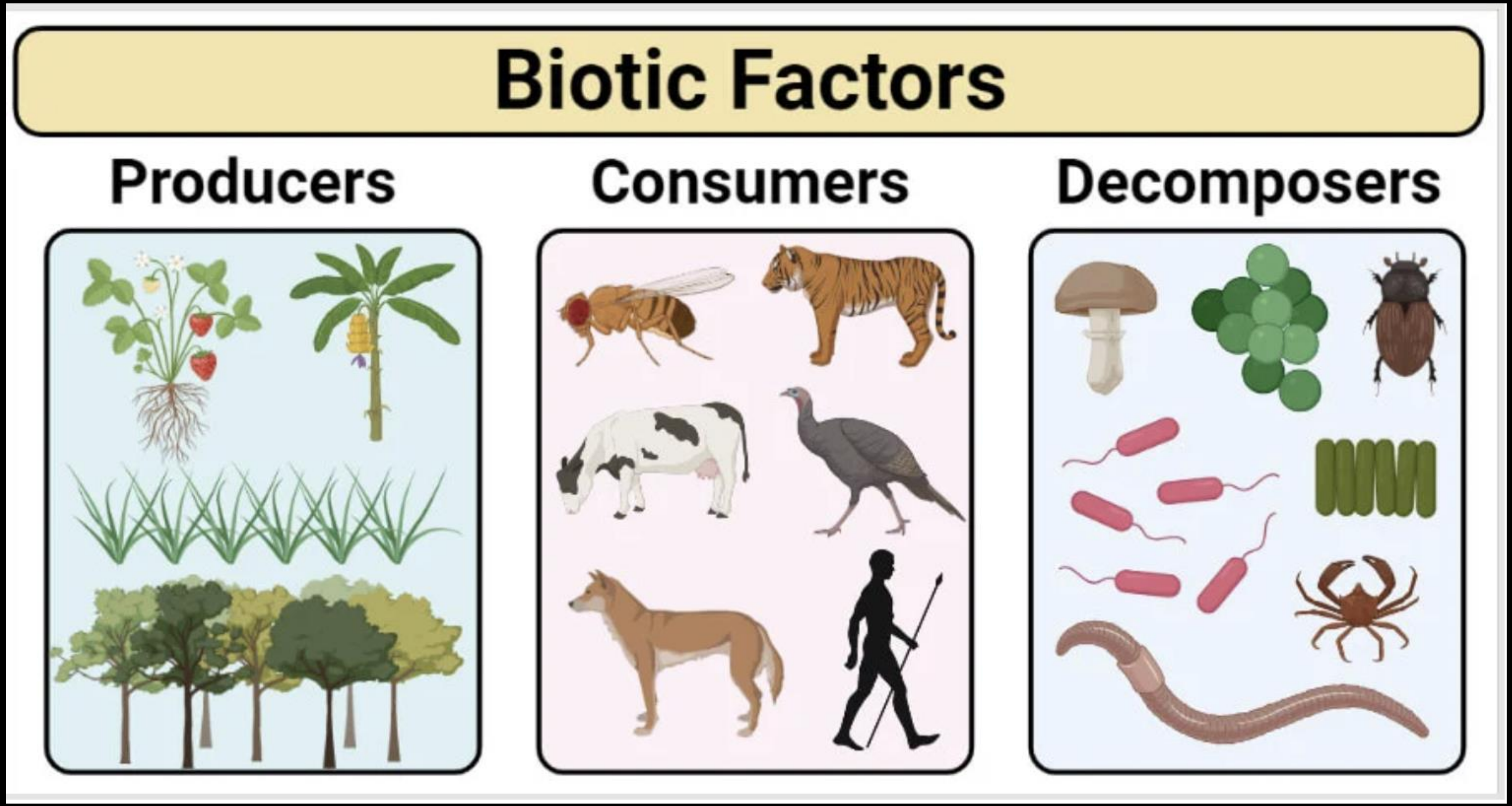
Fundamentals of Ecology: Ecosystem Concepts

The abiotic factors in an ecosystem include all the *non-living* elements of the ecosystem. Abiotic components include sunlight, temperature, moisture, wind or water currents, soil type, and nutrient availability. Abiotic factors all impact the living elements of an ecosystem.



Fundamentals of Ecology: Ecosystem Concepts

Biotic components describes the living component of an ecosystem. Biotic describes all living things: plants, animals, fungi, and bacteria (autotrophs and heterotrophs).

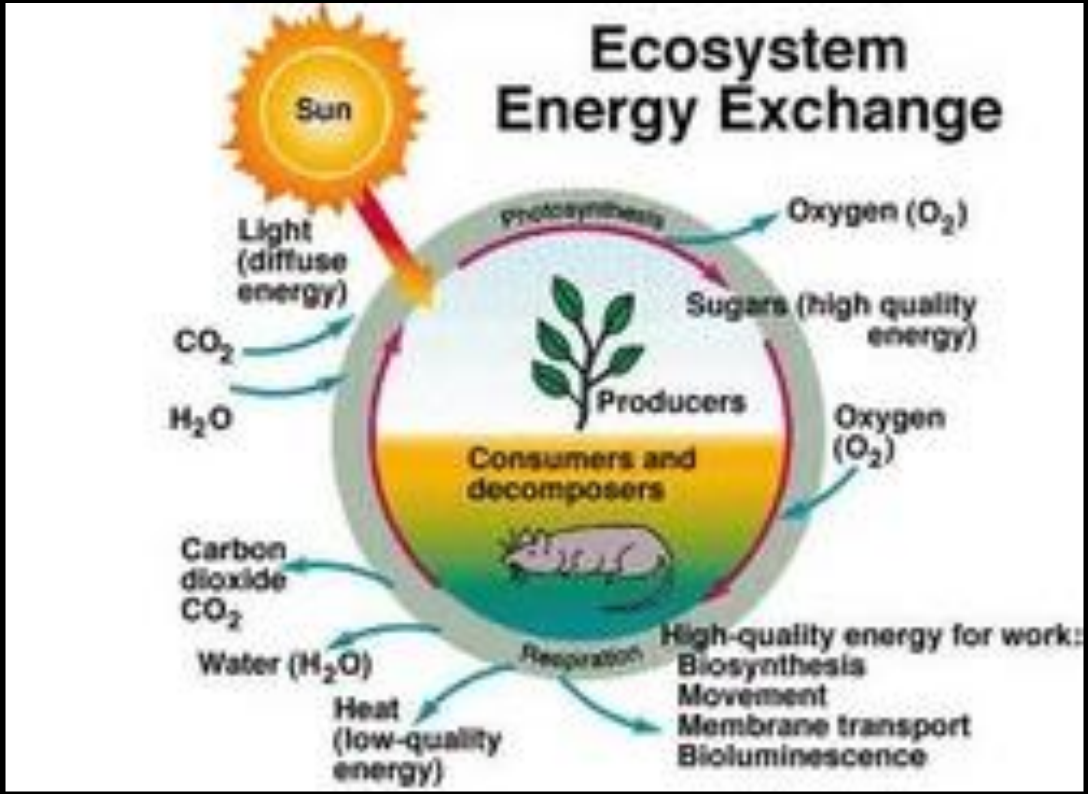


Energy Flows and Material Cycling

There are two critical ideas about how ecosystems function:

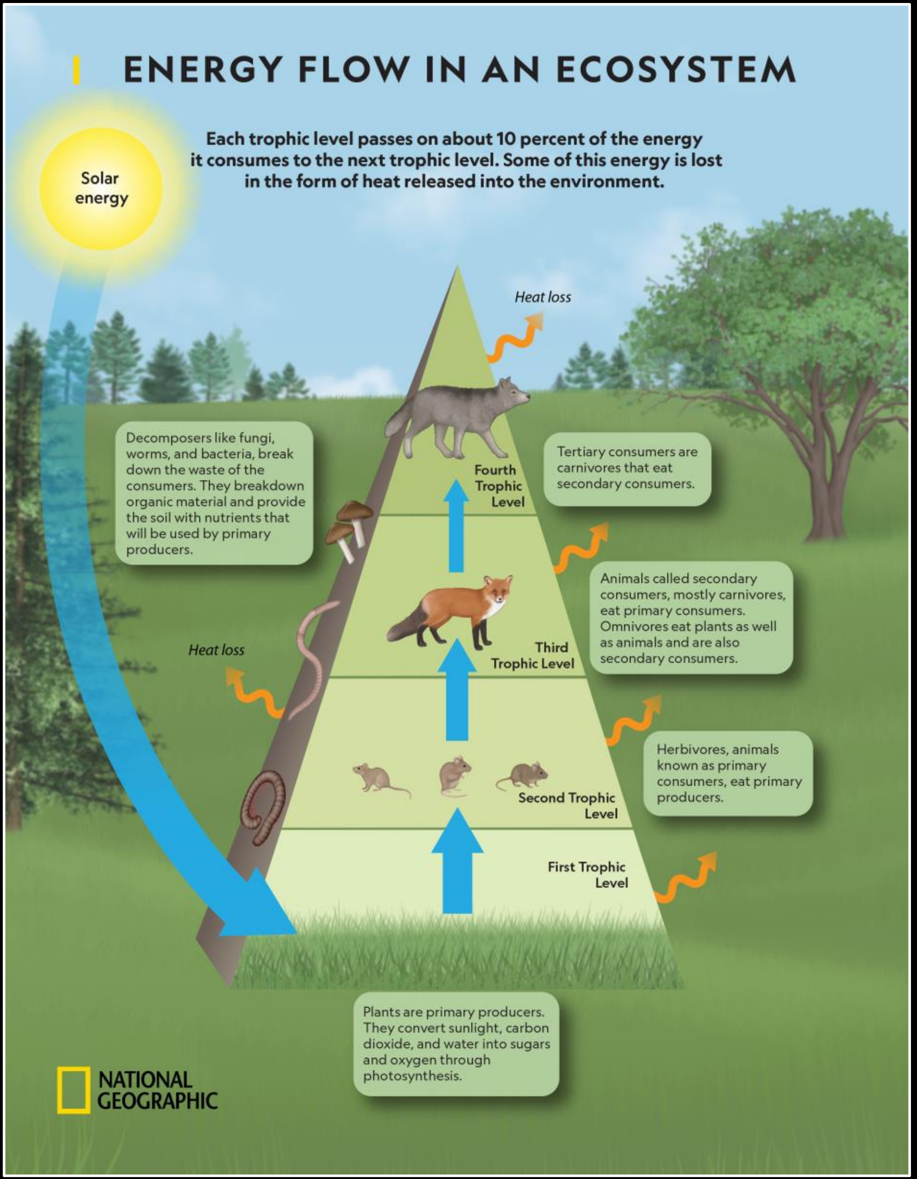
1. ecosystems have energy flows,
2. ecosystems cycle materials.

These two processes are linked, but they are not the same.



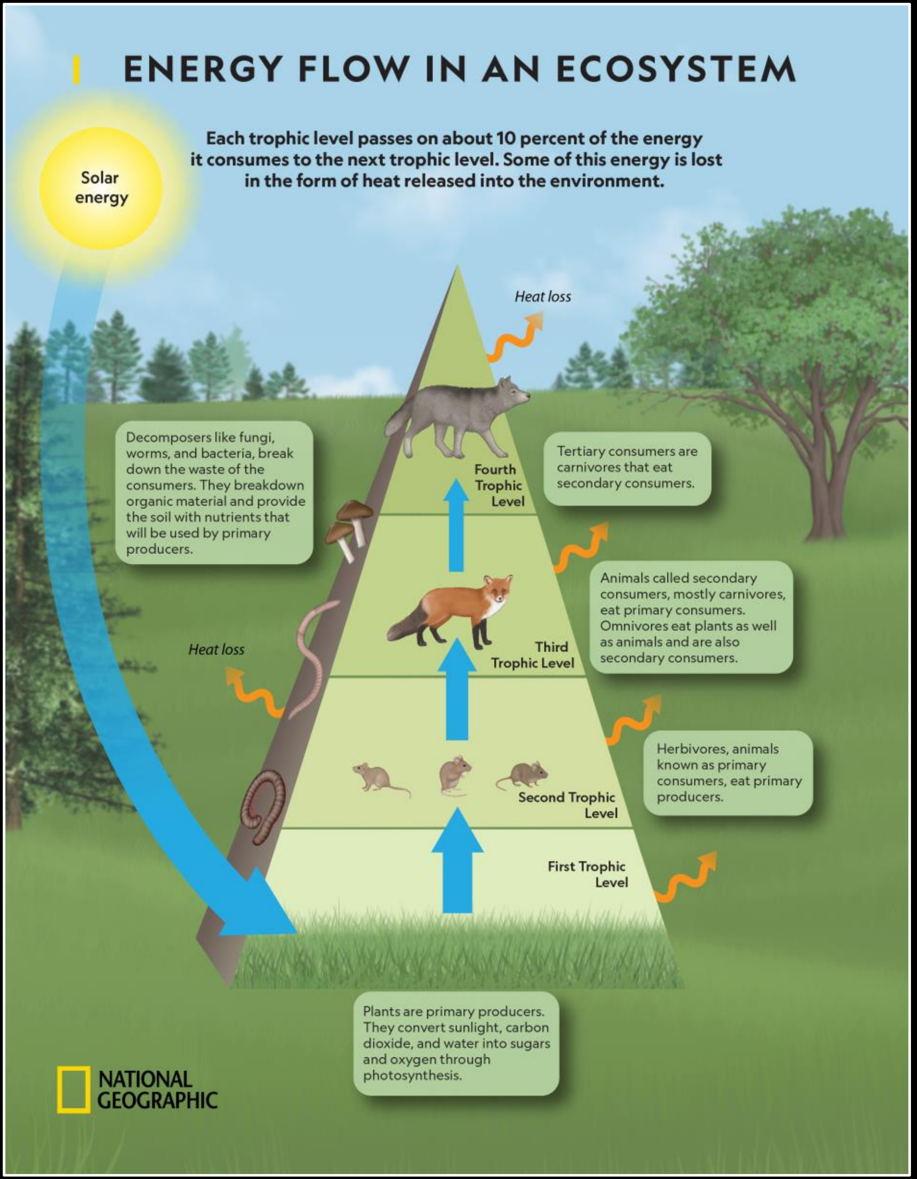
Energy Flows and Material Cycling: Energy Flows

The transformations of energy in an ecosystem begin first with the input of energy from the sun. Energy from the sun is captured by the process of photosynthesis. Virtually all energy available to organisms originates in plants. Because it is the first step in the production of energy for living things, it is called primary production.



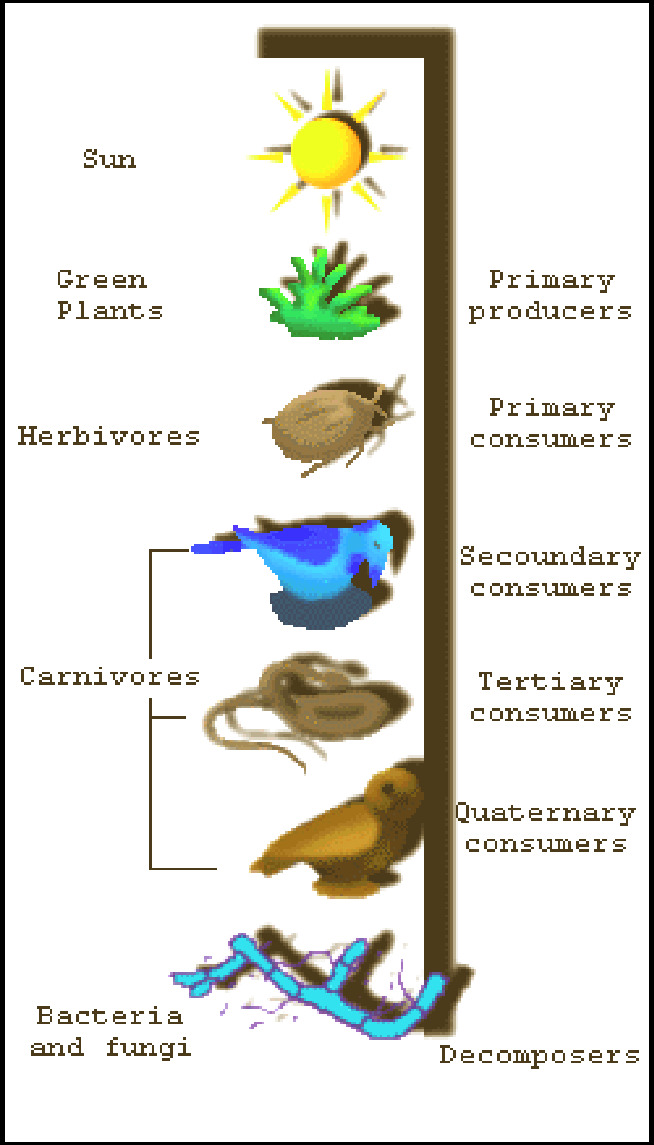
Fundamentals of Ecology: Energy Flows

Herbivores obtain their energy by consuming plants or plant products, carnivores eat herbivores, and detritivores consume the droppings and carcasses of us all.



Fundamentals of Ecology: Energy Flows

The flow of energy between trophic levels is an important unifying characteristic of all ecosystems. The first trophic level of photosynthetic plants use only the Sun’s energy, which provides energy for herbivores in the second trophic level. Herbivores, in turn, pass some of their energy to carnivores of the third trophic level. Decomposers, including bacteria and fungi, obtain energy from all other trophic levels.

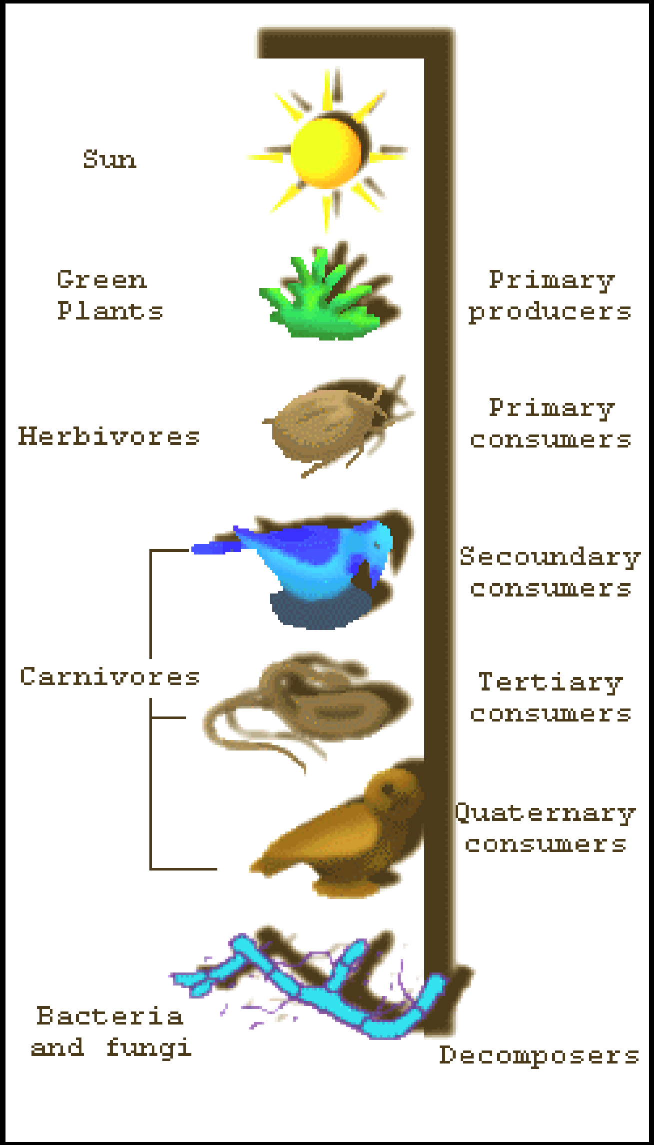


PRACTICUM: Trophic Levels & Energy Flows

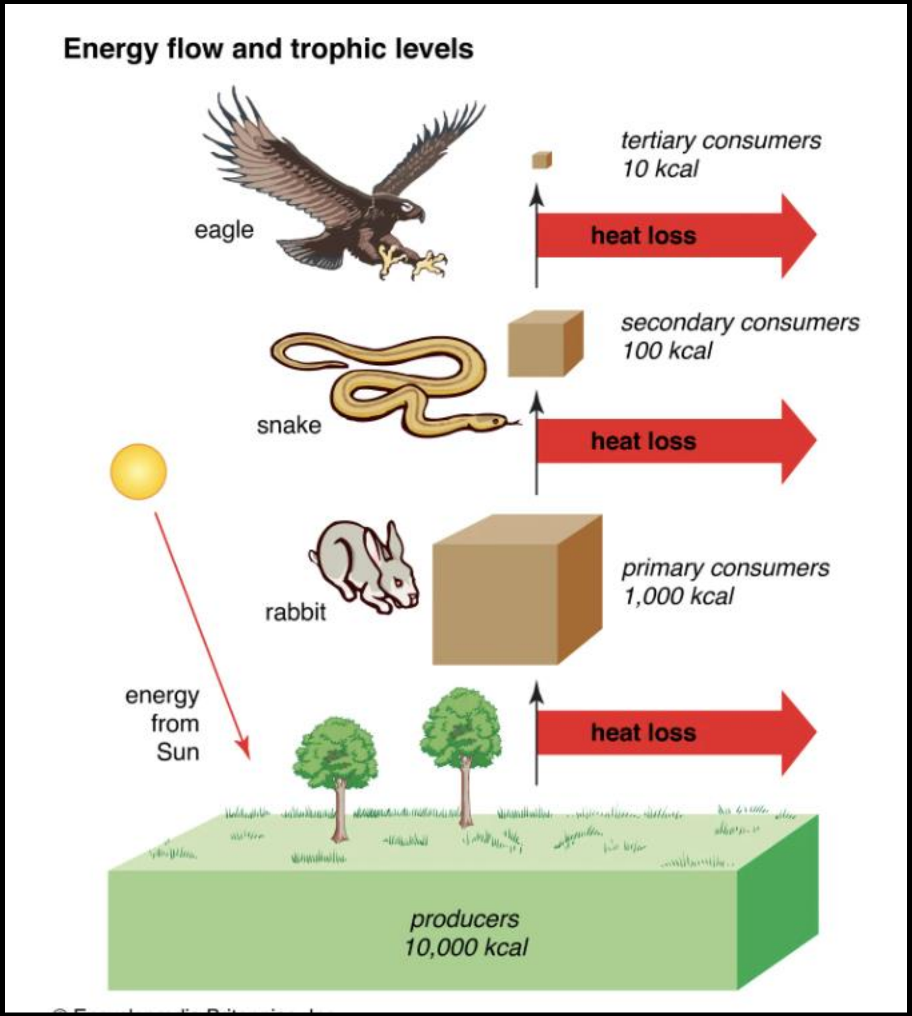
Energy flow in an ecosytem can be observed through species interactions across different trophic levels.

Practicum: Species Interactions, Trophic Levels, and Energy Flows.

Visit the FTI palm farm to identify different trophic levels and instances of transfer of energy between ecosystem components (species interactions or trophic functions).



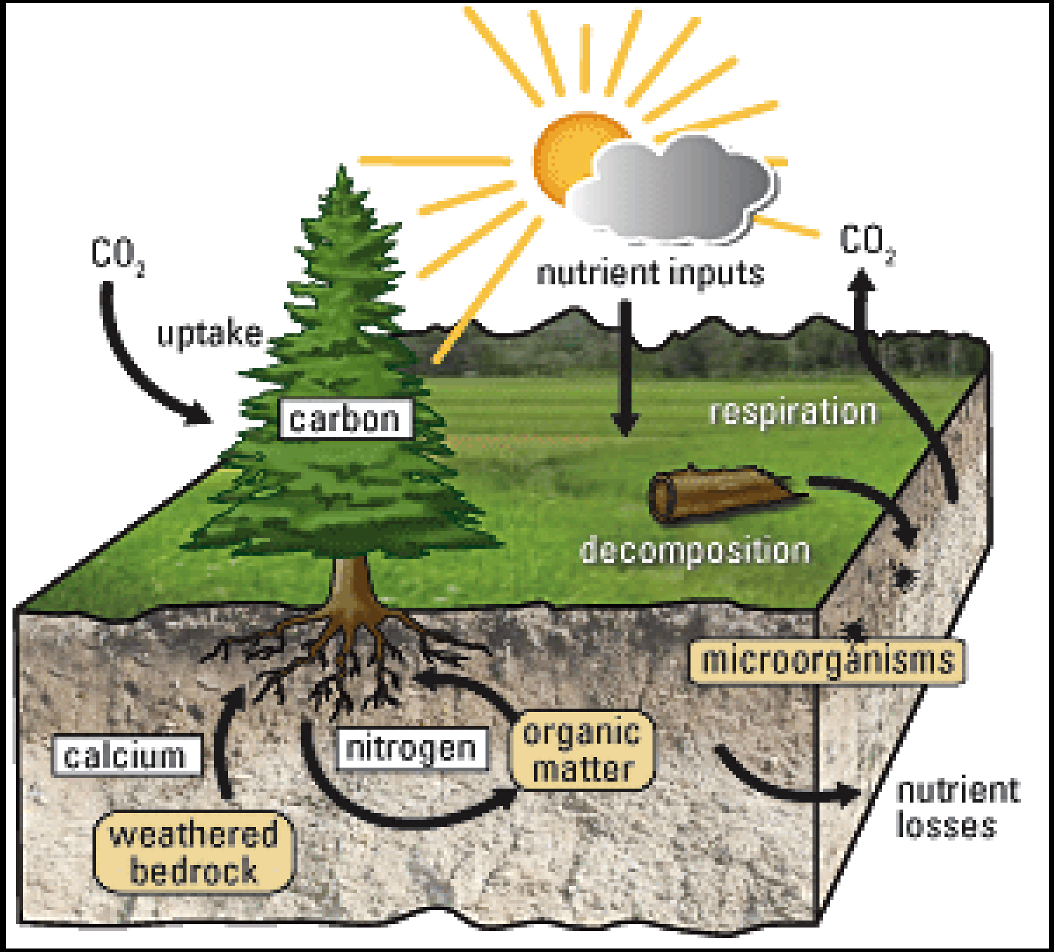
Fundamentals of Ecology: Energy Flows



In each energy transfer from one trophic level to another, most of the available energy cannot be recovered in a useful form; it eventually radiates into space as waste heat. In fact, only about 10% of the energy available at one trophic level normally finds its way to the next. Thus, as energy flows through an ecosystem, it must be replaced continuously.

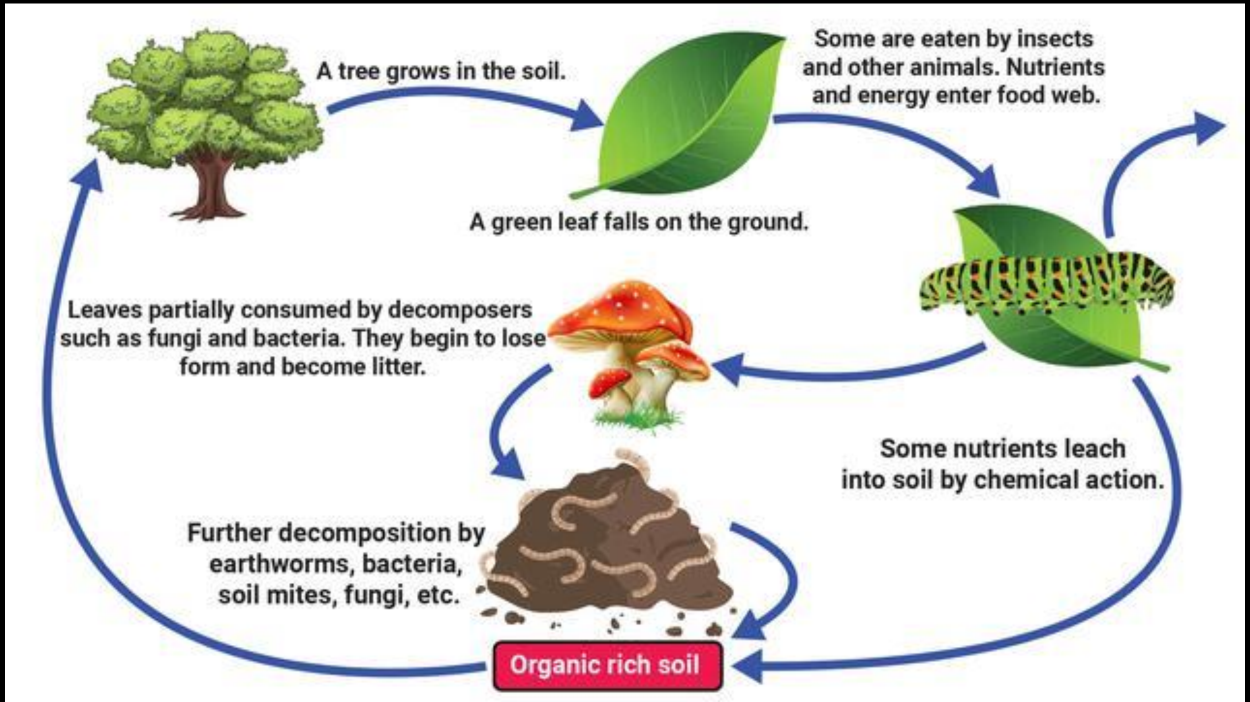
Energy Flows and Material Cycling: Nutrient Cycling

Nutrient Cycling: Elements such as carbon, nitrogen, or phosphorus enter living organisms in a variety of ways. Plants obtain elements from the surrounding atmosphere, water, or soils. Animals may also obtain elements directly from the physical environment, but usually they obtain these mainly as a consequence of consuming other organisms.



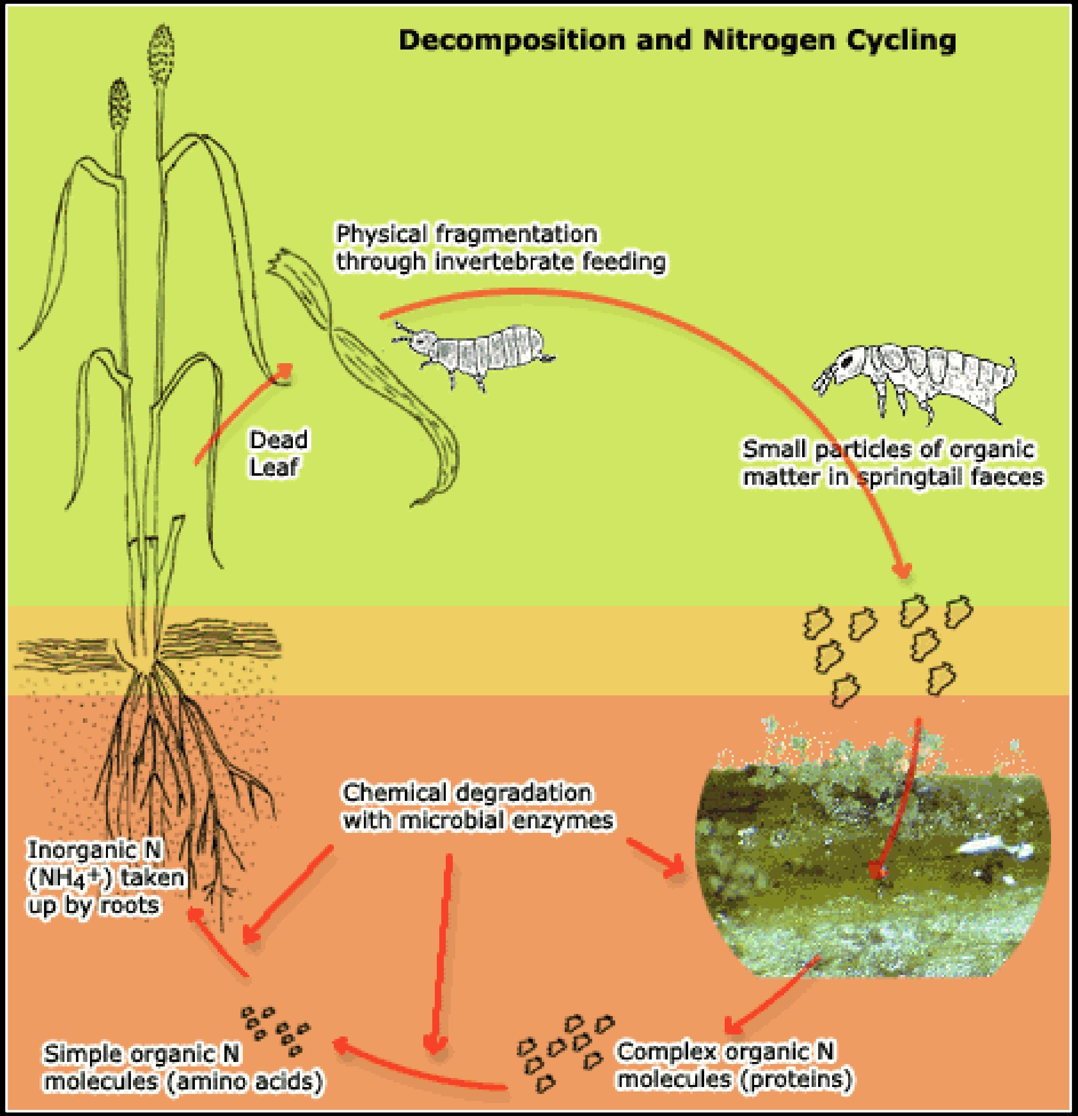
Energy Flows and Material Cycling: Nutrient Cycling

Organic materials are transformed biochemically within the bodies of organisms and through excretion or decomposition, they are returned to an inorganic state (e.g., inorganic material such as carbon, nitrogen, and phosphorus). Bacteria complete this process through decomposition or mineralization.

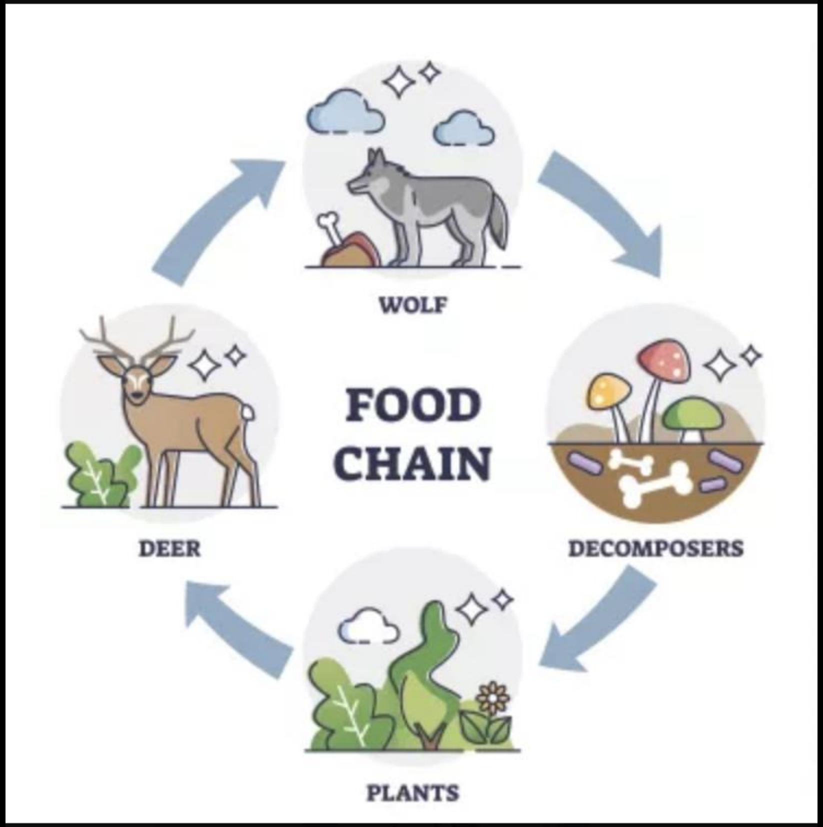


Energy Flows and Material Cycling: Nutrient Cycling

The elements are cycled endlessly between their biotic and abiotic states within ecosystems. Those elements whose supply tends to limit biological activity are called nutrients.

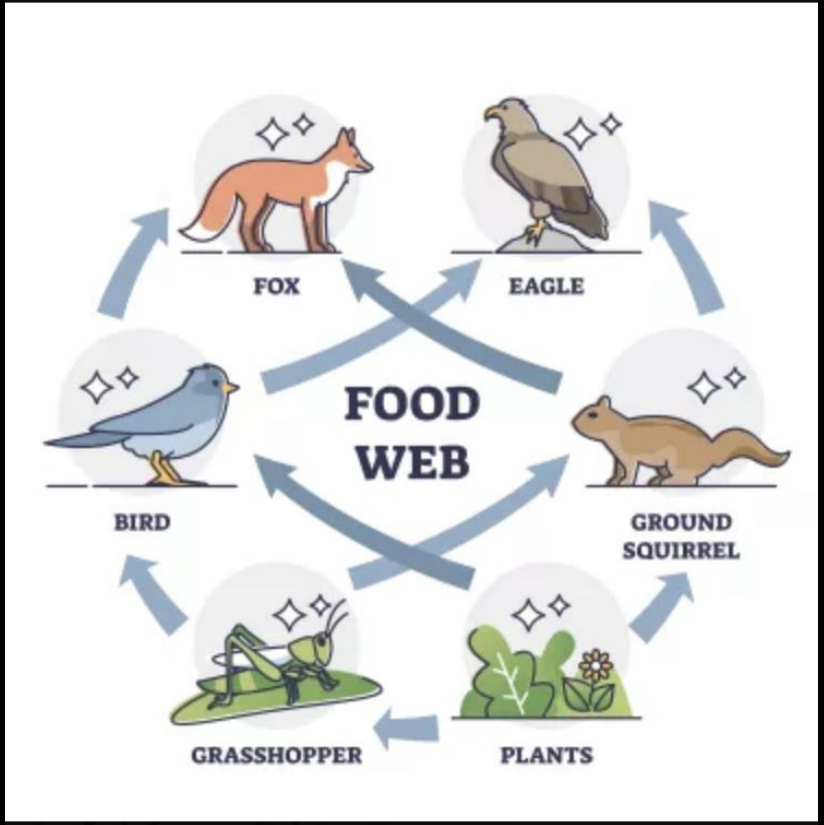


Energy Flows and Material Cycling: Food Chains & Webs



The concept of food chains is too simple, as in reality the organization of biological systems is much more complicated than can be represented by a simple "chain". Food chains are simplifications of complex relationships.

Energy Flows and Material Cycling: Food Chains & Webs



A food web is a more realistic and accurate depiction of energy flow. Food webs are networks of feeding interactions among species. There are many food links and chains in an ecosystem, and we refer to all of these linkages as a food web.

Population Ecology: Definitions

Population ecology is the study of populations in relation to their environment, including environmental influences on density and distribution, age structure, and population size.

Population Ecology: Definitions

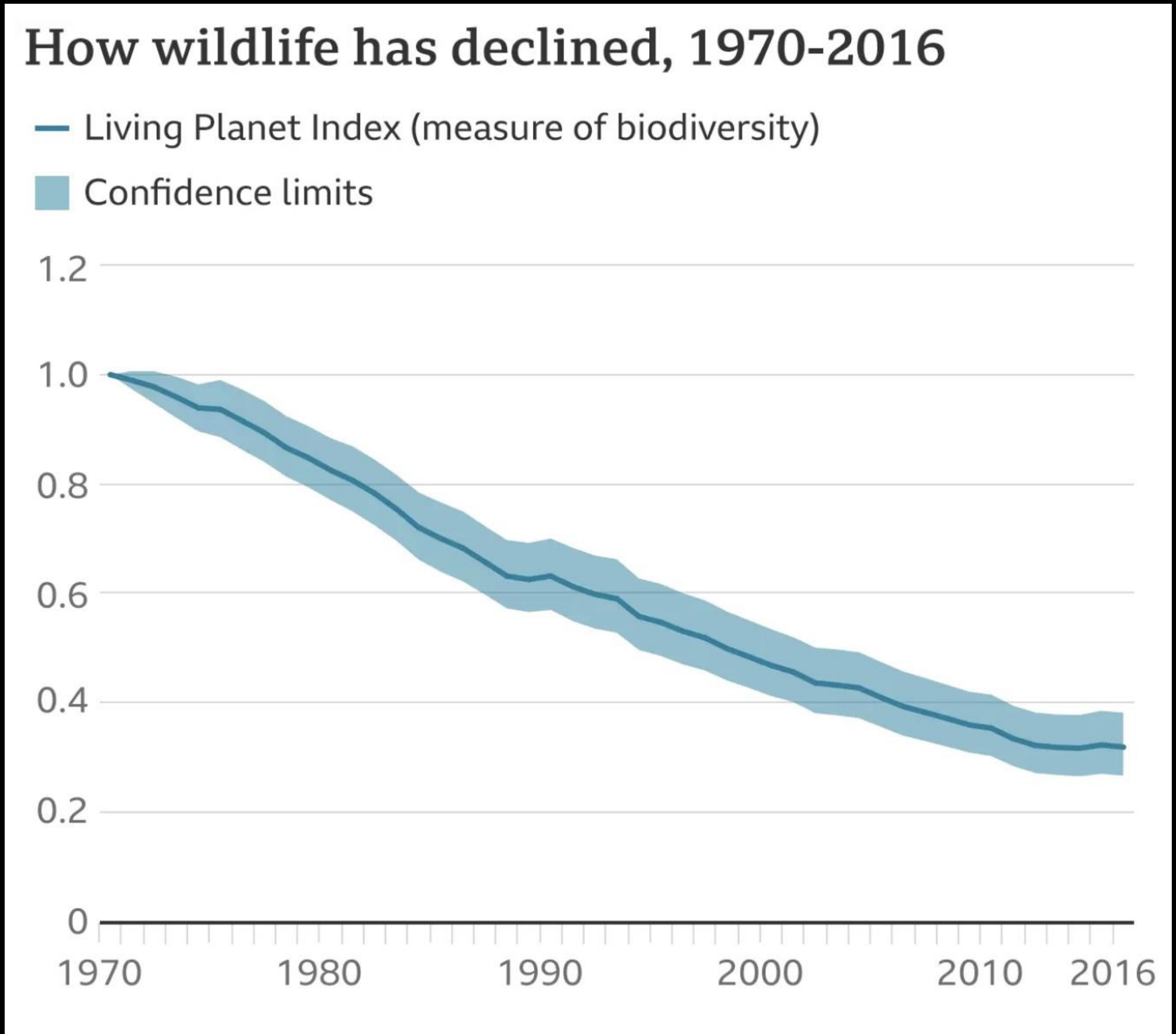
Population: individuals of the same species present in the same place at the same time. Populations are described by their boundaries and size.

Community: the assemblage of populations of different species present in the same place at the same time.

Population Ecology: Definitions

A population has 3 components:

1. *Size*: How many animals in the population?
2. *Density*: What is the Number of individuals per unit area.
3. *Distribution*: where are individuals located within a specific region.



Population Ecology: Definitions

Three basic questions in Population Ecology…

- What determines the geographic distribution of a species?
- What determines the abundance of individuals in a local population?
- What maintains diversity of species within a community?

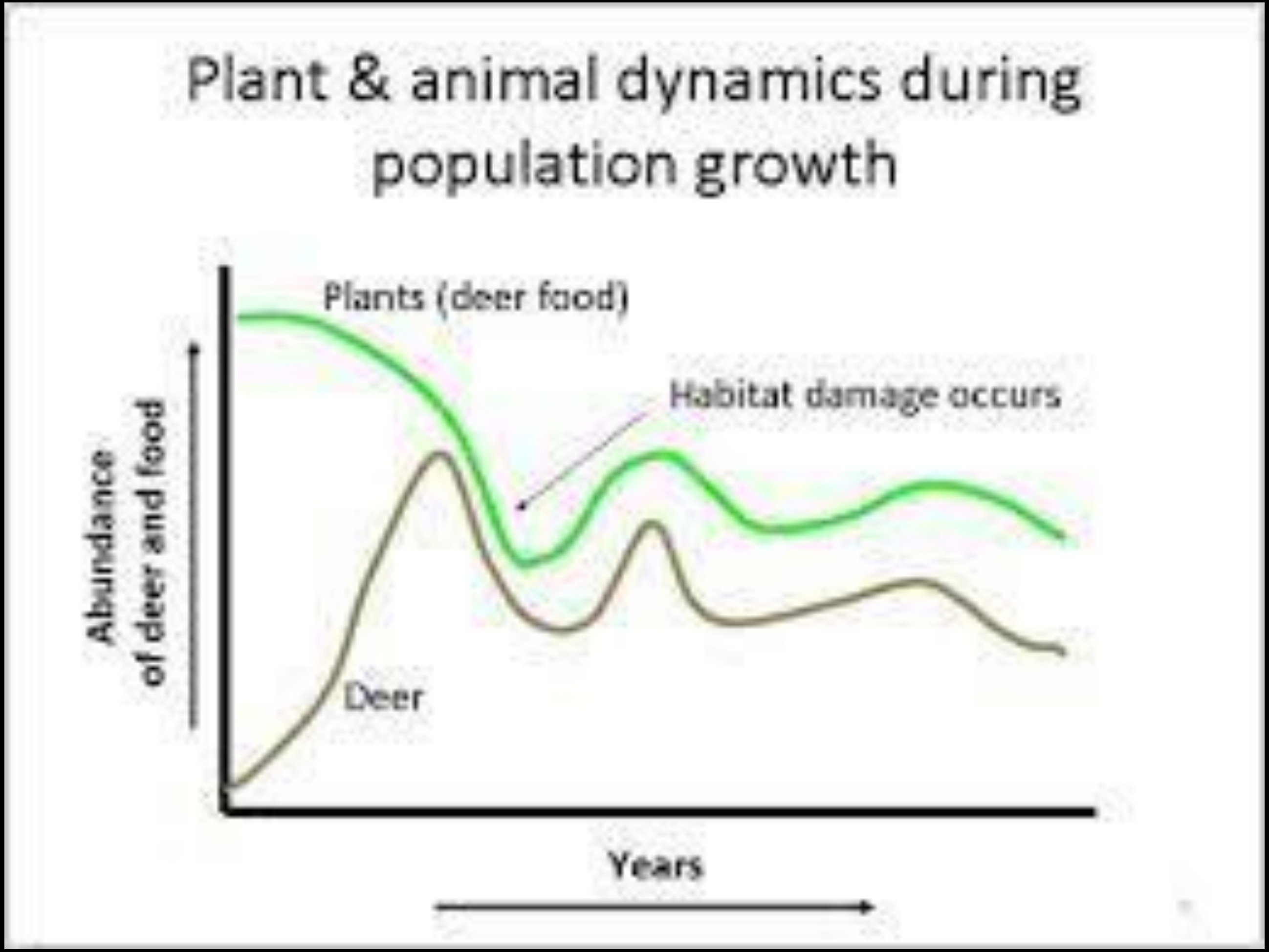
Population Ecology : Definitions

The range of a species is the geographical area within which that species can be found. Within that range, distribution is the general structure of the species population, while dispersion is the variation in its population density.

- Chimpanzees, for example, are widely distributed and live in a wide variety of habitats, from humid evergreen forests, through mosaic woodlands and deciduous forest, to dry savanna woodlands.

Population Ecology : Definitions

Population size is the actual number of individuals in a population. The population size in an undisturbed ecosystem is limited by the food supply, competition, predation, and parasitism.

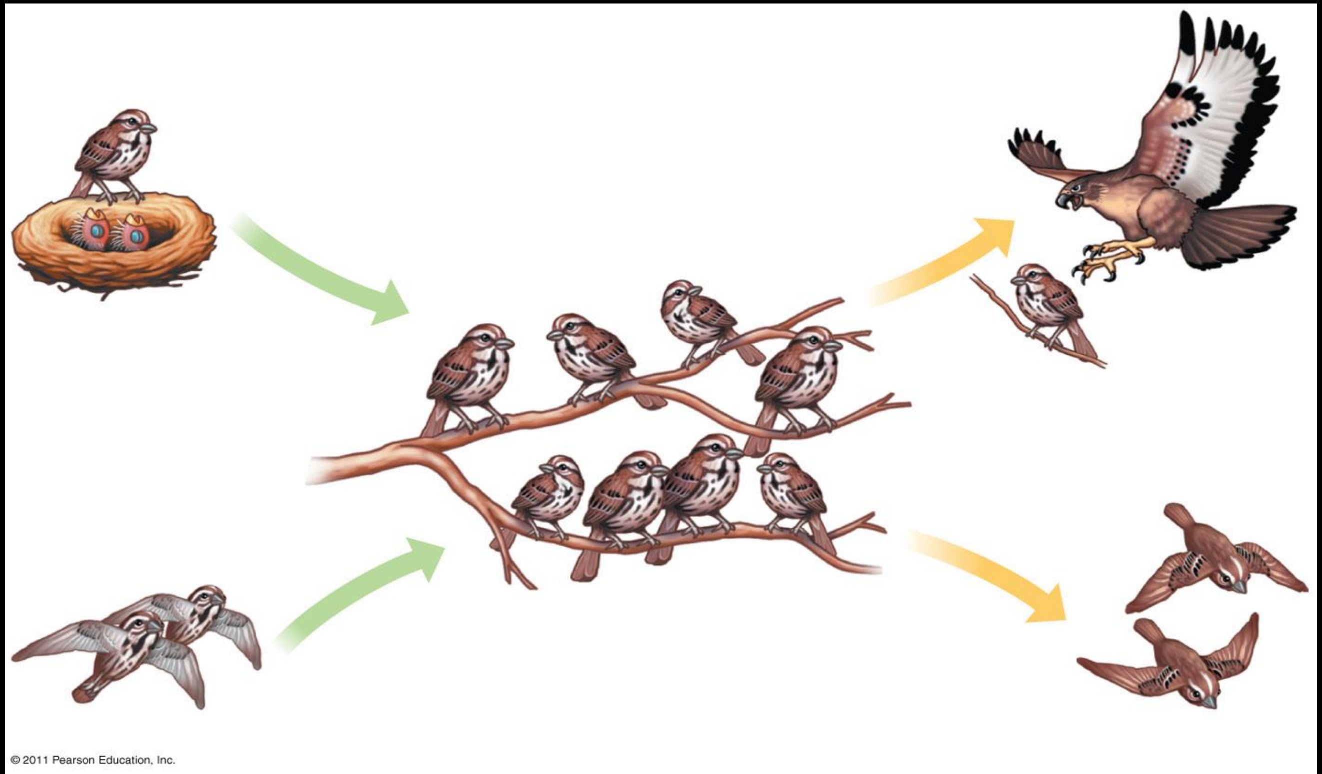


Population Ecology: Definitions

Four variables govern changes in population size:

1. Births
2. Deaths
3. Immigration
4. Emigration

A population *gains* individuals by birth and immigration and *loses* individuals by death and emigration.



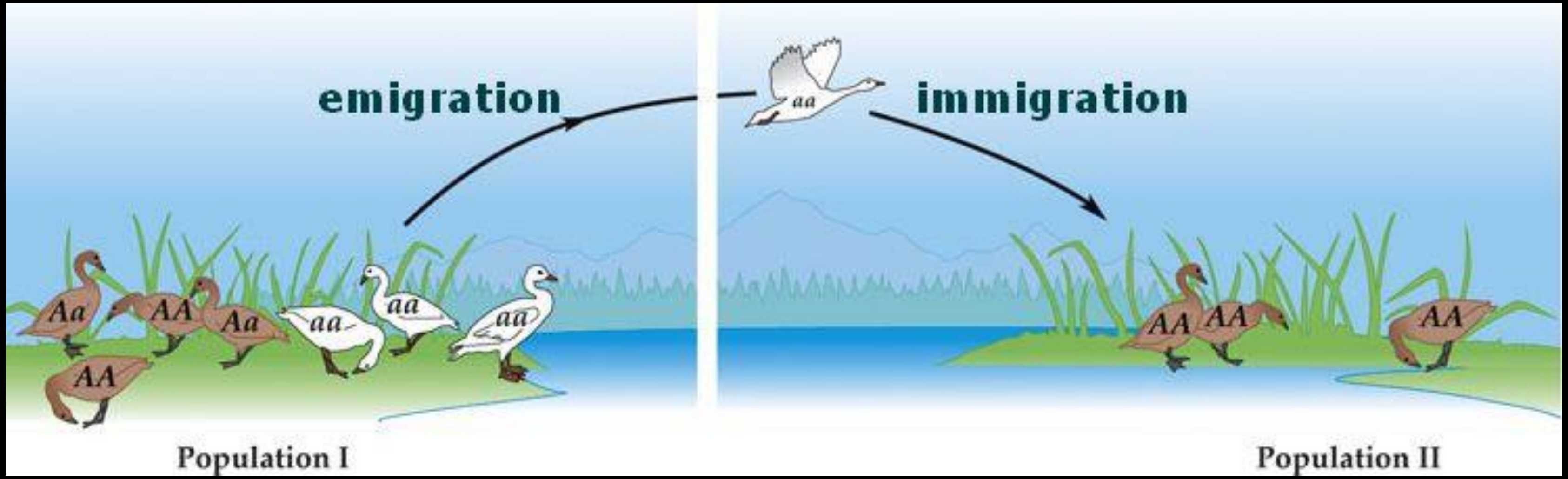
Population Ecology : Definitions

Population density is a measurement of population size per unit area, i.e., population size divided by total land area. Population density may change as a result of natural or human induced factors.

Population Ecology: Definitions

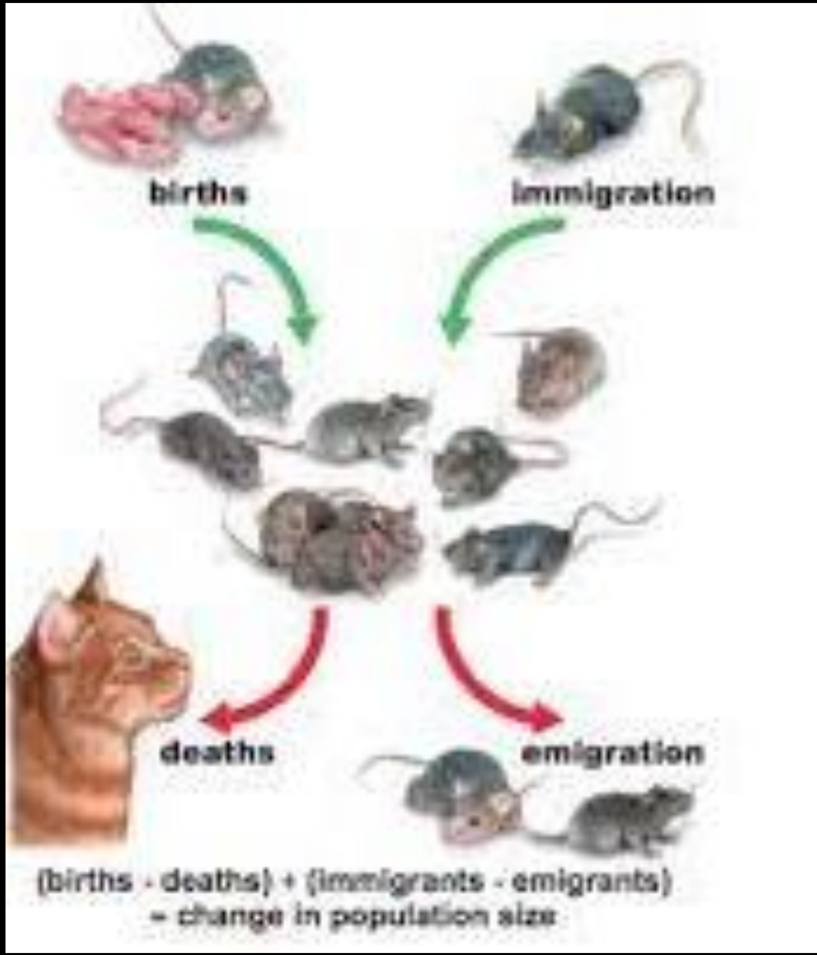
Density is the result of processes that *add* individuals to a population and those that *remove* individuals.

- Immigration is the influx of new individuals from other areas.
- Emigration is the movement of individuals out of a population.



Population Dynamics: Definitions

Population growth: Births and deaths determine whether a population increases (births outweigh deaths) or decreases (deaths outweigh births) over time. Often the challenge of rescuing an endangered species amounts to trying to bring birth rates back into balance with death rates.



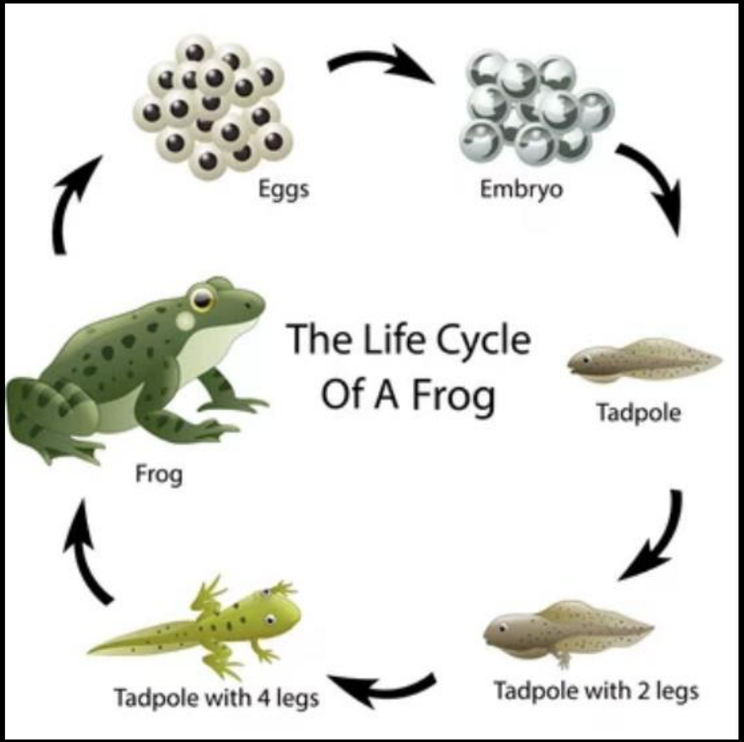
Population Dynamics: Definitions

Populations vary in their capacity to grow. The maximum rate at which a population can increase when resources are unlimited and environmental conditions are ideal is termed the population's biotic potential.

Population Dynamics: Definitions

Each species will have a different biotic potential due to variations in the species' reproductive span (how long an individual is capable of reproducing); the frequency of reproduction (how often an individual can reproduce); “litter size" (how many offspring are born each time); survival rate (how many offspring survive to reproductive age).

Population Dynamics: Definitions

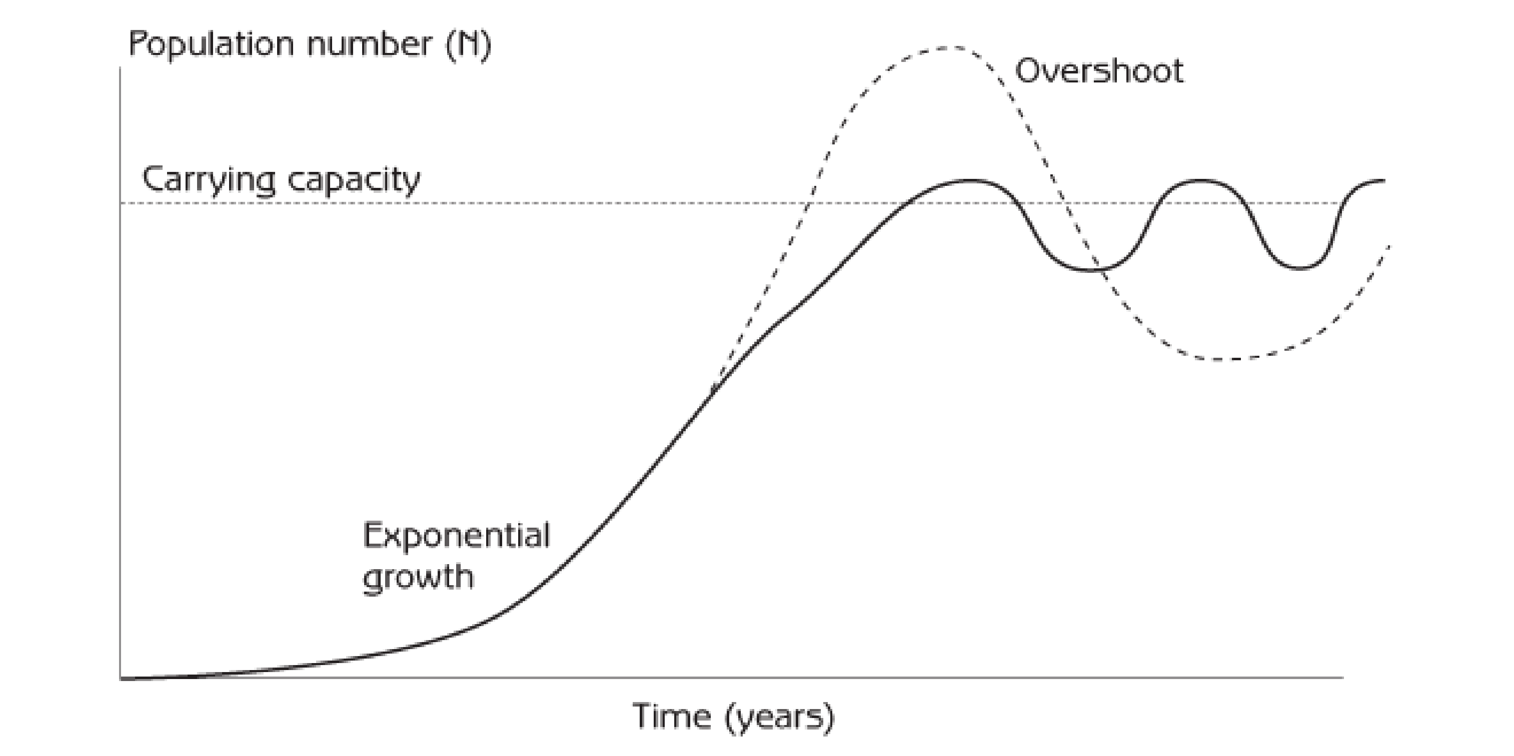


An organism's life history describes the stages that affect its reproduction and survival.

- The age at which reproduction begins
- How often the organism reproduces
- How many offspring are produced during each reproductive cycle

Life history traits are evolutionary outcomes reflected in the development, physiology, and behavior of an organism.

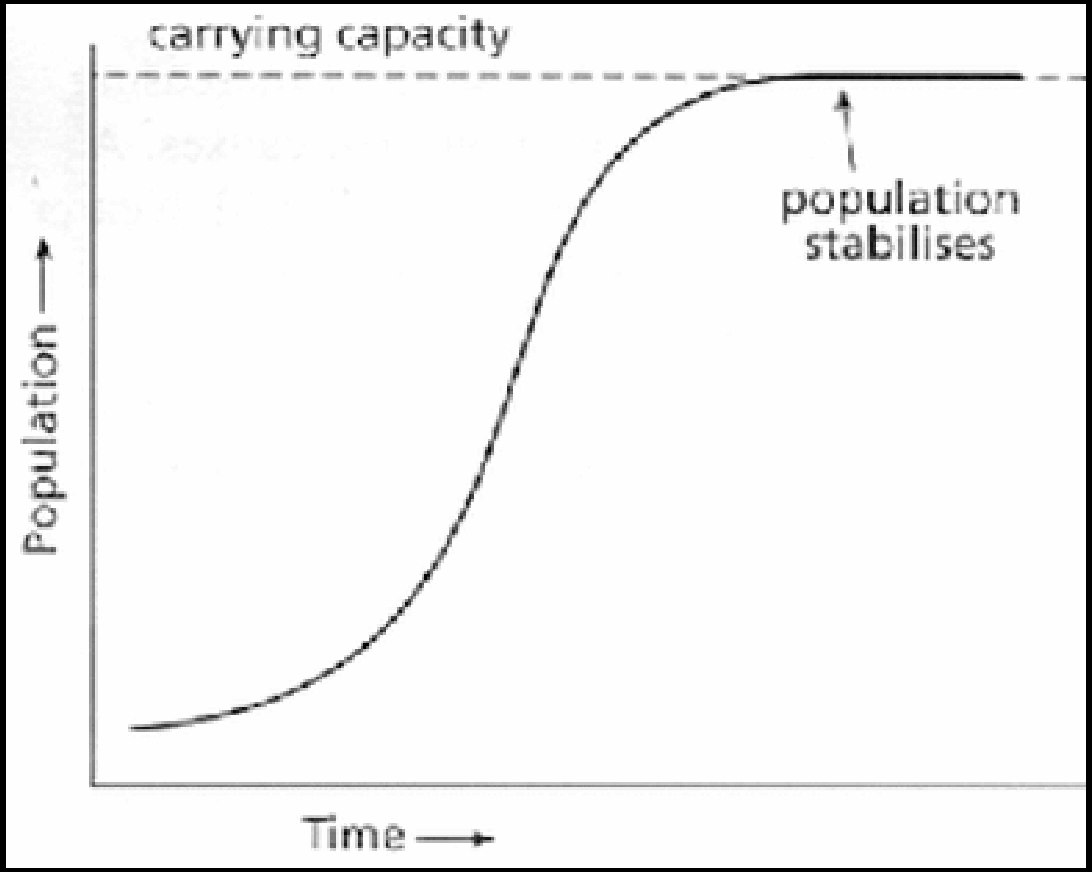
Population Ecology: Population Dynamics



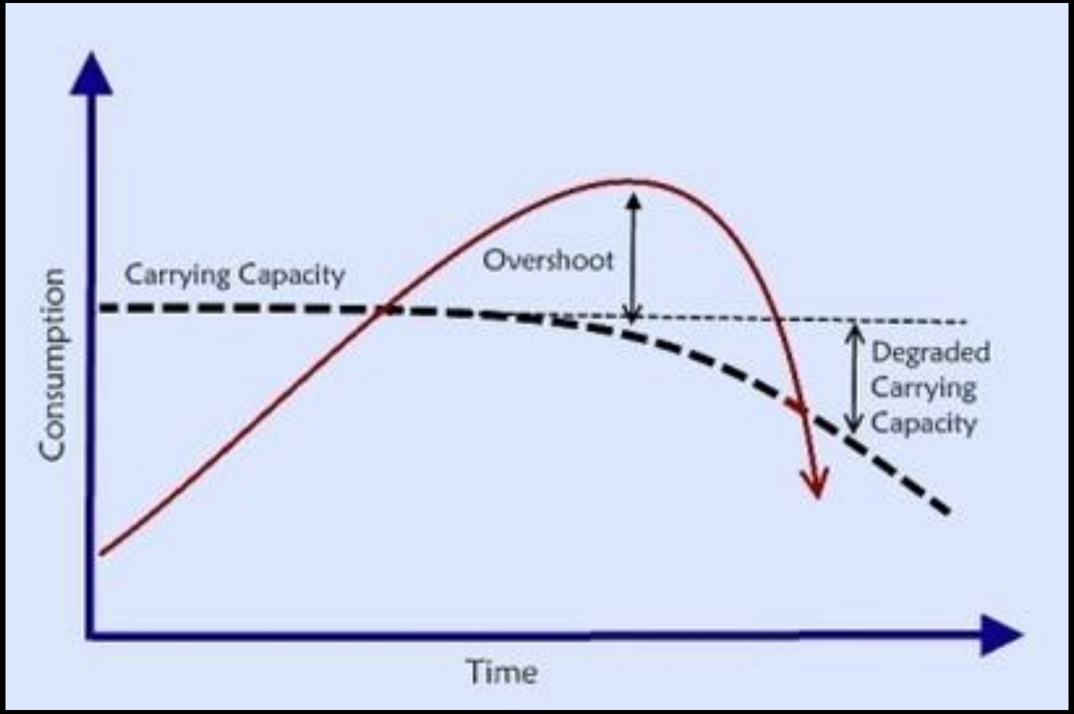
Natural Regulation refers to the fact that there are always limits to population growth in nature. Populations *cannot* grow exponentially indefinitely – they always reach a size limit imposed by the shortage of one or more factors such as water, space, and nutrients or by adverse conditions such as disease, drought and temperature extremes.

Population Ecology: Population Dynamics

Carrying capacity refers to the number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural social, cultural, and economic environment for present and future generations.



Population Ecology: Population Dynamics

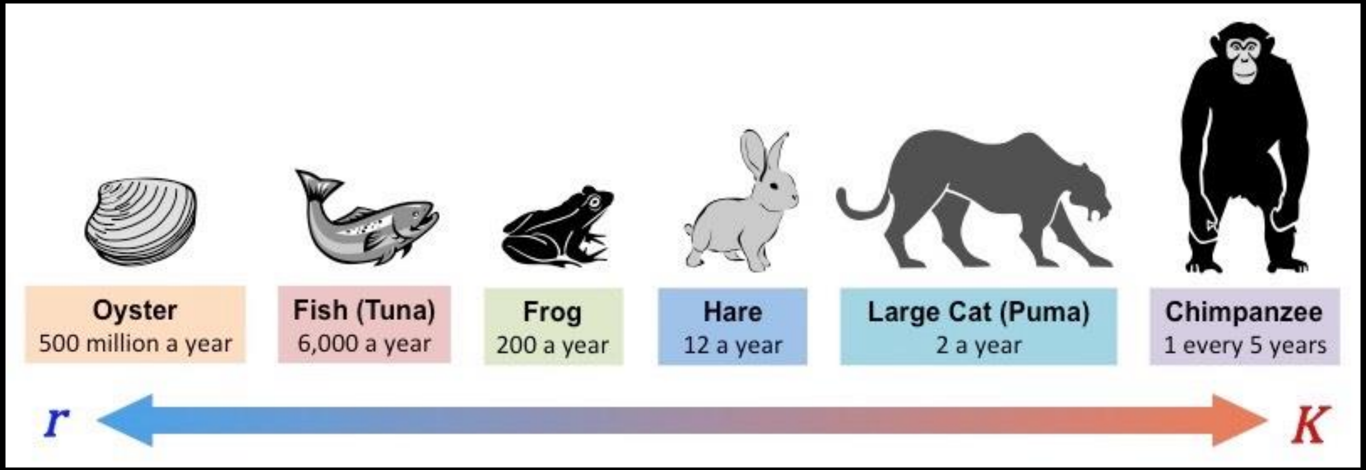


If one basic requirement is in short supply, the carrying capacity is lowered. The requirement(s) that is in shortest supply is the limiting factor(s). Conservation initiatives can increase an area's carrying capacity by improving the kind or amount of the limiting factor, i.e., food, cover, water or space that is in short supply.

Population Ecology: Population Dynamics

The concepts of *K*-selection and *r*-selection help us to understand the life history of wildlife species.

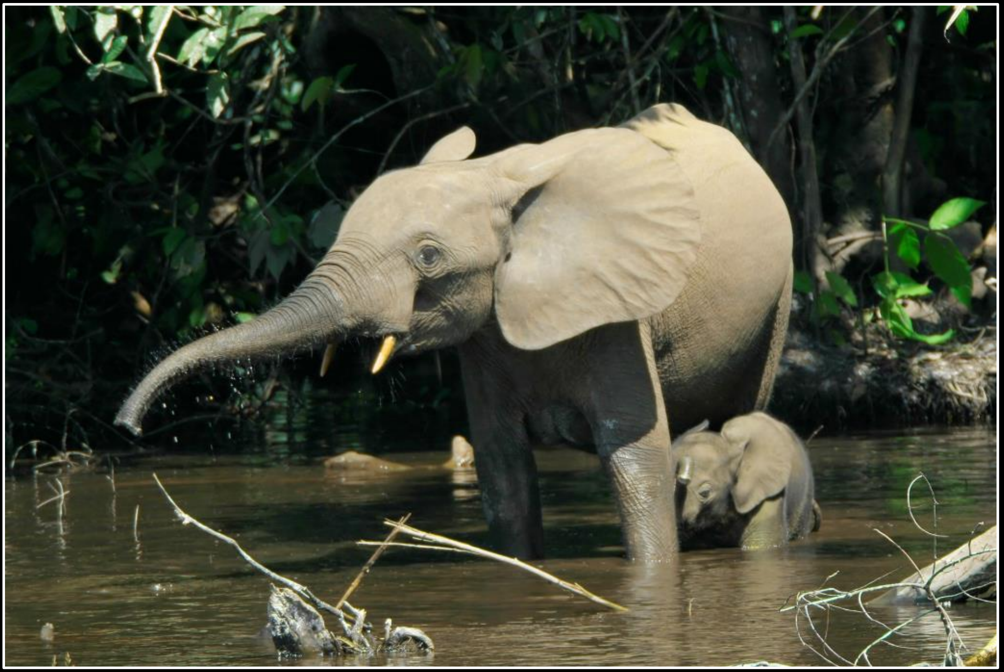
- *K*-selection, or density-dependent selection, selects for life history traits that are sensitive to population density
- *r*-selection, or density-independent selection, selects for life history traits that maximize reproduction



Population Ecology: Population Dynamics

Class Exercise

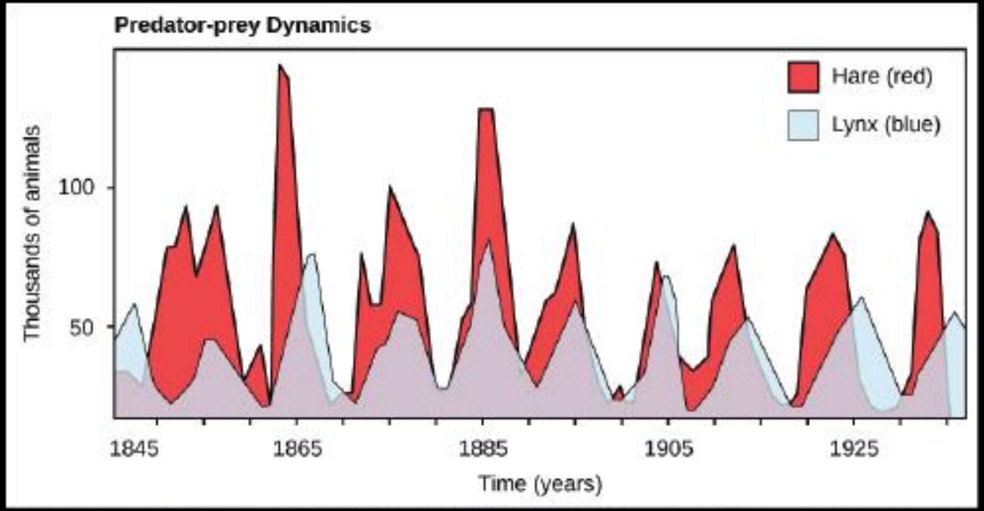
In small groups (2-4 students), list some wildlife species in Liberia that are examples of *K*-selection and *r*-selection



Population Ecology: Population Dynamics

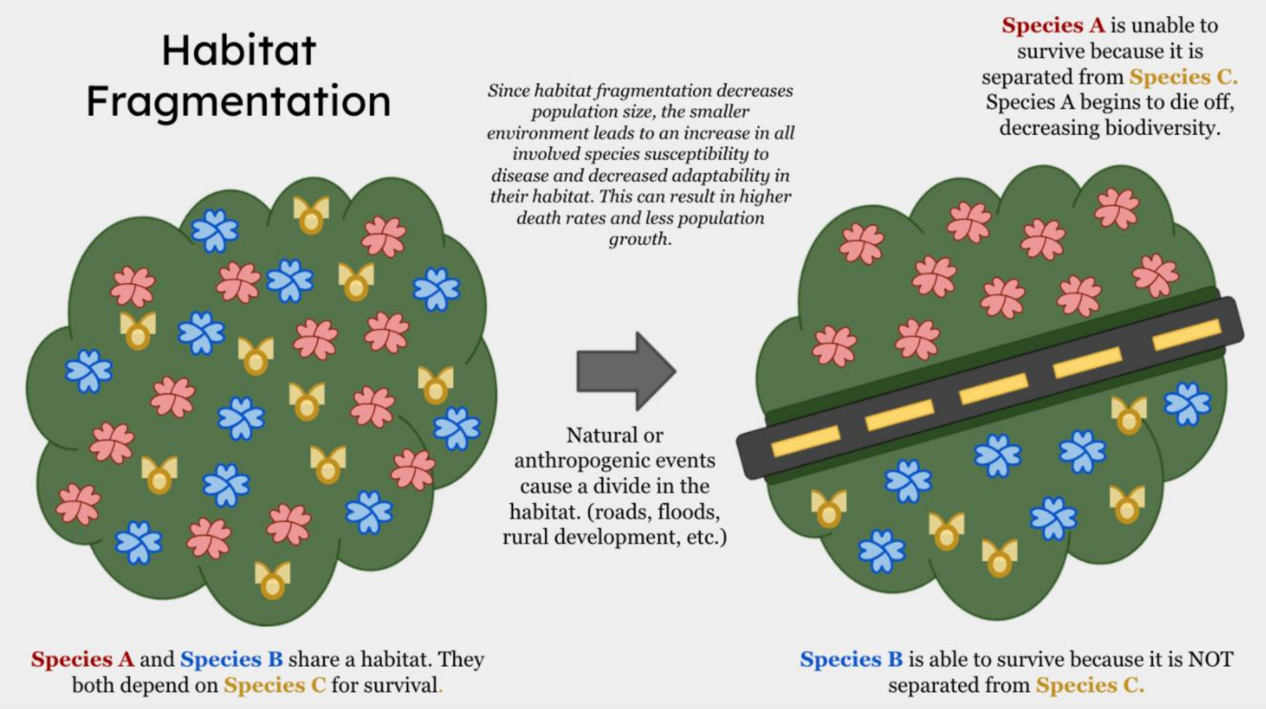
In density-dependent (K) populations, birth rates fall and death rates rise with population density. Density-dependent birth and death rates are affected by many factors, such as competition for resources, territoriality, disease, predation, pollution, etc.

In density-independent (r) populations, birth rate and death rate do not change with population density.



Population Ecology: Population Dynamics

Fragmentation occurs when groups of animals living in the wild become separated from other groups of the same species. Population fragmentation is often caused by habitat destruction.



Species Interactions: Competition and Predation

One can conceptualize competition as occurring horizontally on the same resource level, while predation takes place vertically between different resource levels. Because the use of a limited resource by one species decreases availability to the other, competition lowers the fitness of both.

Species Interactions: Competition and Predation

The coexistence of populations under competition and predation indicates that these populations have accommodated themselves to each other's presence and have evolved ways to survive in spite of the pressures. In other words, they have co-evolved.

Species Interactions: Commensalism

Commensalism occurs when one species benefits, and the other species is neither benefited nor harmed.

Species Interactions: Mutualism

Mutualism describes an interaction that benefits both species. Pollination is a common mutualistic interaction as is the relationship between alga and fungus that form lichens.

PRACTICUM: Species Interactions

Take a walk to the FTI arboretum and see what species interactions. Take notes on the kinds of interactions (mutualism, competition, etc.) you can observe.