

**2018 ECOLOGY – YEAR 2 (2018)**  
**PART ONE – GENERAL PRINCIPLES OF ECOLOGY**

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National Rules Committee Chairman – Life Science

**DISCLAIMER** - This presentation was prepared using draft rules. There may be some changes in the final copy of the rules. The rules which will be in your Coaches Manual and Student Manuals will be the official rules. **BE SURE TO CHECK THE 2017 EVENT RULES** for EVENT PARAMETERS and TOPICS FOR EACH COMPETITION LEVEL

**TRAINING MATERIALS:**

- **Training Power Point** presents an overview of material in the training handout
- **Training Handout** presents introductory topic content information for the event
- **Sample Tournament** has sample problems with key
- **Event Supervisor Guide** has event preparation tips, setup needs and scoring tips
- **Internet Resource & Training Materials** are available on the Science Olympiad website at [www.soinc.org](http://www.soinc.org) under Event Information.
- A **Biology-Earth Science CD, an Ecology CD** as well as the **Division B and Division C Test Packets** are available from SO store at [www.soinc.org](http://www.soinc.org)

**ECOLOGY CONTENT: - each section has a separate handout**

- General Principles of Ecology (about 1/3)  
*It is recommended that for State and Regional Tournaments the general Ecology principles be applied to the local and regional ecology.*
- Terrestrial Ecosystems of North America (about 1/3)
- Human Impact on Terrestrial Ecosystems (about 1/3)

**The Ecology event will concentrate on the US Terrestrial Ecosystems**

**YEAR 1 – 2017**

- *forests*
- *taiga*
- *tundra*

**YEAR 2 - 2018**

- *grasslands*
- *deserts*

## Part I: General Principles of Ecology

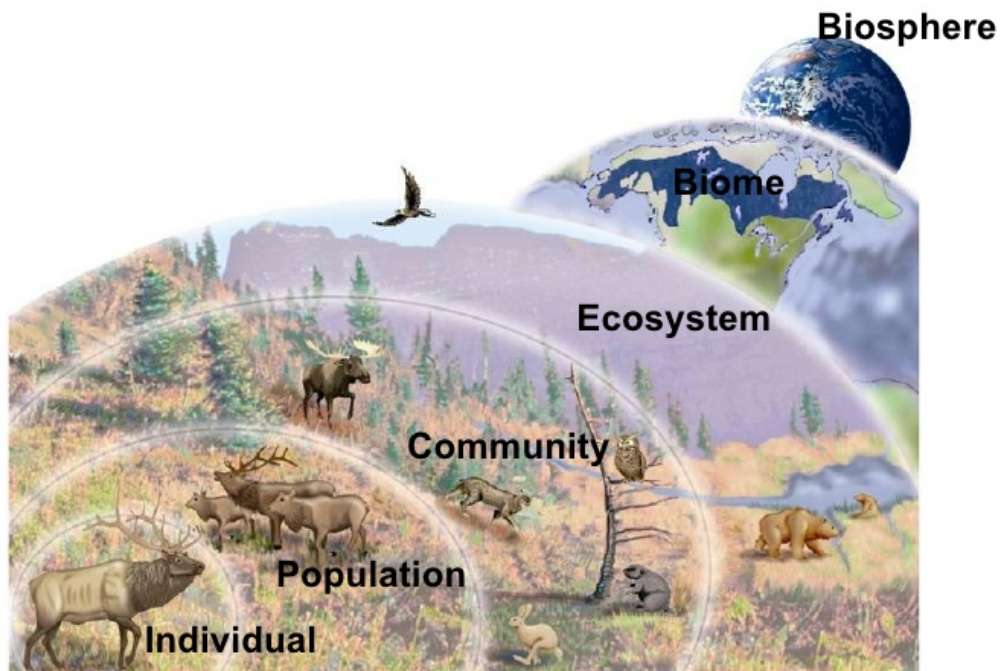
### *General Principles of Ecology:*

- **Ecology and the abiotic environment**
  - ecology – introduction and terms
    - **ecology** = how organisms interact with one another and with their environment
    - **environment** = biotic (other organisms) and abiotic ( physical factors)
  - natural selection – adaptation
  - soils and nutrients
  - climate
- **Ecology of individual organisms**
  - physiological ecology
  - temperature and water balance
  - light and biological cycles
  - physiological ecology and conservation
- **Ecology of populations** - group of individuals of the same species occupying a common geographical area
  - properties of populations
  - patterns of distribution and density
  - intraspecific competition
  - population dynamics
  - population growth and regulation
  - altering population growth
  - human impact
- **Ecological interactions among species**
  - interactions
  - competitive interactions - interspecific competition, competitive exclusion, resource partitioning
  - predation
  - exploitation
  - symbiosis – mutualism, parasitism, commensalism, amensalism
- **Ecology of communities** - two or more populations of different species occupying the same geographical area
  - closed vs. open communities
  - species abundance and diversity
  - concept of the ecosystem
  - trophic structure of communities – food webs and food chains
- **Ecology of ecosystems** - a community plus its abiotic factors, e.g. soil, rain, temperatures, etc
  - energy flow within ecosystems – energy-flow and bio-mass pyramids
  - community succession and stability
  - nutrient recycling – biogeochemical cycles
- **Biomes** – weather and climate
  - terrestrial biomes – tundra, taiga, temperate forest, grassland, desert, tropical forest
  - aquatic biomes – marine, freshwater
- **Biosphere** - the portion of the earth that contains living species. It includes the atmosphere, oceans, soils and the physical and biological cycles that affect them

## *Ecology and the Abiotic Environment*

- **Ecology and the abiotic environment**
  - ecology – introduction and terms
    - **ecology** = how organisms interact with one another and with their environment
    - **environment** = biotic (other organisms) and abiotic ( physical factors)
  - natural selection – adaptation
  - soils and nutrients
  - climate
- **Four levels of ecological organization:**
  - **Population** - group of individuals of the same species occupying a common geographical area
  - **Community** - two or more populations of different species occupying the same geographical area Populations and communities include only biotic factors
  - **Ecosystem** - a community plus its abiotic factors, e.g. soil, rain, temperatures, etc.
  - **Biosphere** - the portion of the earth that contains living species. It includes the atmosphere, oceans, soils and the physical and biological cycles that affect them

## Levels of Organization



## *Ecology of Individuals*

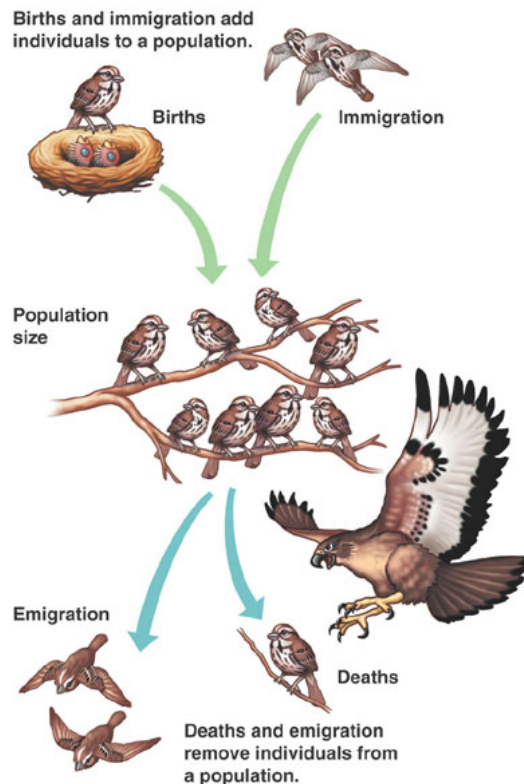
- physiological ecology
- temperature and water balance
- light and biological cycles
- physiological ecology and conservation

## *Ecology of Populations*

- **Population Ecology** = the study of how populations interact with their environment
- **Population** = group of individuals of the same species occupying a common geographical area
- **Habitat** - where a species normally lives

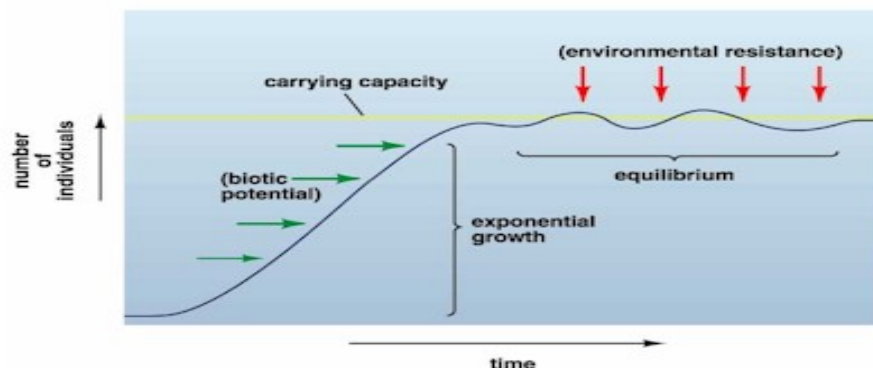
**Characteristics of populations** - Each population has certain characteristics:

- **Population size** = number of individuals making up its gene pool
- **Population density** = number of individuals per unit of area or volume, e.g. persons/square mile
- **Population distribution** = the general pattern in which the population members are dispersed through its habitat, may be: **Clumped** (most common), **Uniformly** dispersed (rare), or **Randomly** dispersed
- **Age structure** defines the relative proportions of individuals of each age: **Pre-reproductive**, **Reproductive**, and **Post-reproductive**
- **Population size and growth**



Population size is dependent on births, immigration, deaths, and emigration

- **Zero population growth** designates a near balance of births and deaths
- **Exponential growth:** If birth and death rates of a population remain constant they can be combined into one variable  $r$  = net reproduction per individual per unit time (rate of increase)
- **Population growth may be represented mathematically as:  $G = rN$**  Where  $G$  = population growth per unit time,  $r$  = rate of increase and  $N$  = the number of individuals. When plotted against time a graph in the shape of a J will be obtained denoting **exponential growth**, i.e. one variable increases much faster than the other
- As long as per capita birth rates remain even slightly above per capita death rates, a population will grow exponentially - with ever-increasing rates and shorted "doubling times"
- It took 2 million years for the world's human population to reach 1 billion, yet it took only 12 years to reach the fifth billion
- If a population lives under ideal conditions it may display its **biotic potential** - the maximum rate of increase under ideal conditions. Few populations live under ideal conditions because a number of factors limit their growth
- **Limiting factor** - any resource that is in short supply, e.g. food, minerals, light, living space, refuge from predators, etc.
- **Carrying capacity** = maximum number of individuals of a species or population a given environment can sustain. Each habitat or area can only support so many individuals
- Because of limiting factors populations rarely exhibit J shaped growth curves
- **Logistic growth**
- Early on populations will exhibit very rapid growth but as they near the carrying capacity they will level off is called **logistic growth** and it produces an **S shaped curve**
- Logistic growth is **density dependent**, i.e. the growth is affected by the density of individuals.
- *For example* - 26 reindeer were introduced onto an island off the coast of Alaska in 1910. Within 30 years the herd increased to 2,000. However, overgrazing reduced the food supply and the population crashed to 8 animals by 1950
- *High density and overcrowding* put individuals at greater risk of being killed, e.g. predators, parasites and pathogens have greater numbers of prey and hosts in a smaller area to interact
- **Bubonic plague** swept through Europe in the 14th century, killing at least 25 million. The disease spread rapidly in overcrowded cities where sanitary conditions were poor and rats were abundant
- Population size and growth may also be controlled by **density-independent factors**, e.g. adverse weather, floods, droughts, cold temperatures

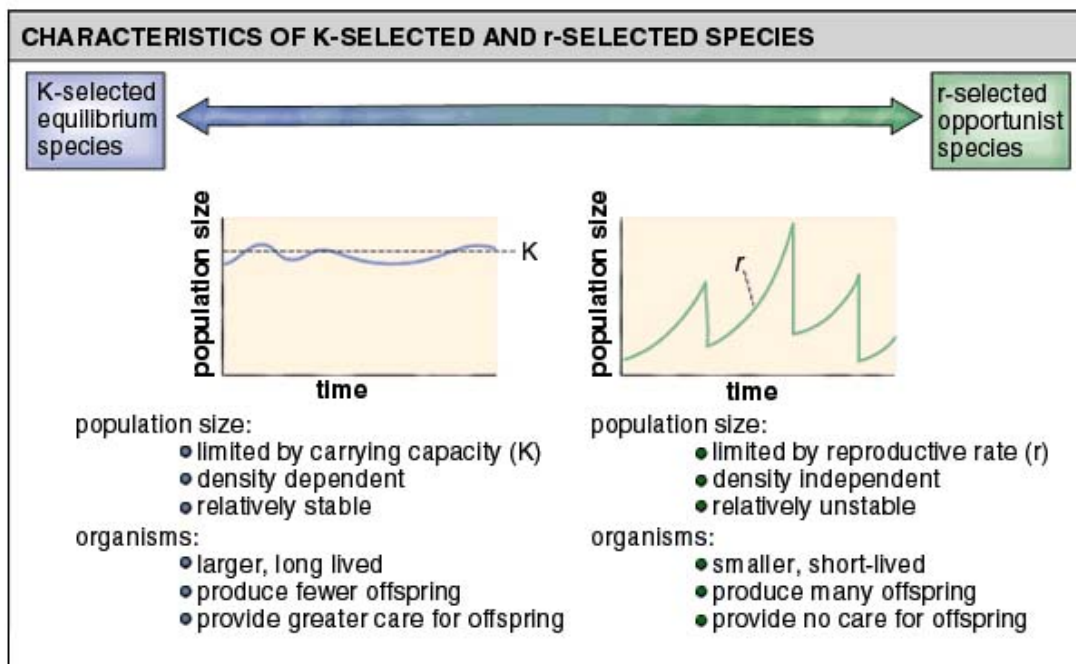


## Life history patterns

- Not all individuals in a population are the same age.
- Different populations may have very different **age structures** and these will determine their growth patterns
- Age structure refers to the proportions of pre-reproductive, reproductive and post-reproductive age individuals in a population. The age structure of a population will determine its future
- Each species has a characteristic life span and the probability of dying increases with age
- Population ecologists, as well as insurance companies track **cohorts** and construct **life tables** for populations
- **Cohort** = a group of individuals born at the same time, e.g. baby boomers are a large group of individuals born just after World War II
- A **life table** is an age-specific death schedule. Such a schedule is often converted to a more palatable **survivorship** schedule. For each age interval there is an predicted life expectancy or survivorship
- Ecologists divide populations into age classes and assign birth rates and mortality risks to each class. Absolute population numbers mean very little unless their age structure is known
- For example, population A might have many more members than population B. However, all the members of A might be post-reproductive, whereas population B might consist of mostly pre-reproductive and reproductive age individuals. Population A might be in danger of extinction.

## Life history strategies

- **r-selected organisms** - put most of their energy into rapid growth and reproduction. This is common of organisms that occupy unpredictable environments, e.g. weeds are usually annuals with rapid growth and early reproduction. They produce large number of seeds containing few stored nutrients
- **K-selected organisms** - put most of their energy into growth. They are common in stable environments near carrying capacity, e.g. long lived trees such as redwoods take many years of growth to reach reproductive age





## *Ecology of Communities*

**Community** = two or more populations of different species occupying the same geographical area

- **Community Ecology** = the study of how different species interact within communities
- **Habitat** = the physical place where an organism lives, e.g. a pine forest or fresh water lake
- Some organisms, particularly migratory birds require more than one habitat
- **Niche** = the functional role of an organism in a community, its job or position
- Each species has a **potential niche** - what they could do with no competitors or resource limitations but due to competition and/or resource limitations, most organisms occupy a **realized niche**, the part of the fundamental niche that a species actually occupies in nature

### Species interactions

- **Neutral** - two species that don't interact at all
- **Commensalism** - beneficial to one species but neutral to another, e.g. birds that nest in trees, epiphytes (plants that grow on other plants) such as tropical orchids
- **Mutualism** - an interaction that is beneficial to both species, e.g. plants and their pollinators, plants and animals that disperse their seeds, certain fungi and plant roots
- **Parasitism** - an interaction that benefits one species and is detrimental to another. Note that the host is generally not killed.
- **Predation** - an interaction beneficial to one species and detrimental to another. In this case the prey is killed. Predators are those that kill and eat other animals. Although many organisms eat plants they usually don't kill them because they are a constant supply of food. Prey are killed and eaten.

### Competitive interactions

- Competition has negative effect on both organisms competing for a resource
- Because resources are limited in nature there will always be competition for them
- Competition is the driving force of evolution, those that win leave more offspring
- Types of competition:
  - **Intraspecific** - competition among individuals of the same species, e.g. humans compete against other humans
  - **Interspecific** - competition between different species, e.g. humans compete against a wide variety of species seeking to utilize our food resources
  - The theory of **competitive exclusion** maintains that species who utilize the same resources cannot coexist indefinitely - the "one niche, one species" concept
  - **resource partitioning** - the resources are divided, permitting species with similar requirements to use the same resources in different areas, ways and/or times



### Community stability

- Communities are assemblages of many different species occupying the same geographical area
- Communities are not static, they gradually change over time because the environment changes and species themselves tend to also change their habitats

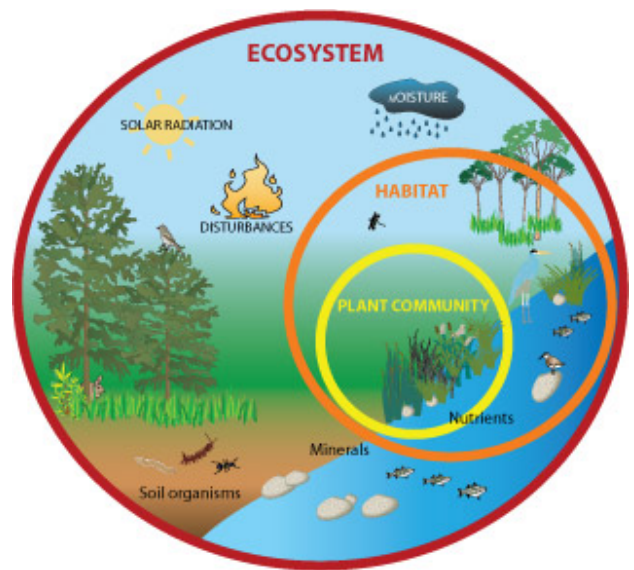
## *Ecology of Ecosystems*

**Ecosystem** = a community of organisms interacting within a particular physical environment or an ecosystem is a community plus its abiotic factors, e.g. soil, rain, temperatures, etc. Virtually all energy on earth comes from the sun, via **photoautotrophs** (primarily plants), and it is ultimately distributed throughout ecosystems.

- **Primary producers** are the autotrophs
- All other organisms are **consumers** Consumers which eat plants are called **herbivores**
- Consumers which eat animals are called **carnivores** Organisms such as humans, which eat both plants and animals, are called **omnivores**
- **Decomposers**, which includes fungi and bacteria, obtain their energy by breaking down the remains or products of organisms
- **Detritivores** are decomposers which eat **detritus** - organic wastes and dead organisms

### Structure of ecosystems

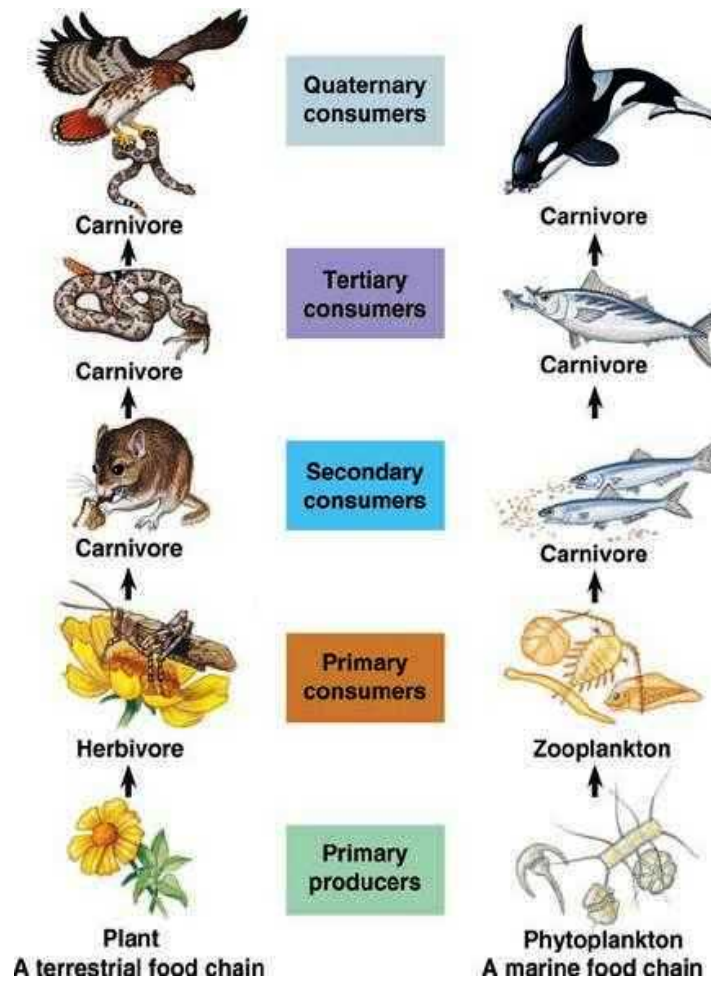
- Energy flows through ecosystems via **food webs**, intricate pathways of energy flow and material cycling
- Ecosystems are arranged by **trophic** (feeding) levels between various producers, the autotrophs, and consumers, the heterotrophs:
- **First trophic level** - contains the autotrophs which build energy containing molecules
- They also absorb nitrogen, phosphorous, sulfur and other molecules necessary for life
- They provide both an **energy-fixation** base as well as the **nutrient-concentration** base for ecosystems
- Two types of autotrophs: Photoautotrophs - plants and some Protista
- Chemoautotrophs - bacteria
- **Second trophic level** - contains the primary consumers which eat the primary producers including herbivores, decomposers and detritivores, e.g. insects, grasshoppers, deer and wildebeest
- **Third trophic level** - contains the secondary consumers, primary carnivores which eat the herbivores, e.g. mice, spiders and many birds
- **Fourth trophic level** - contains the tertiary consumers, secondary carnivores who eat the primary carnivores, e.g. weasel, owl, sharks and wolves.
- Linear **food chains** as described above are probably rare in nature because the same food source may be part of several interwoven food chains and many organisms have several food sources
- Decomposers play a key role in ecosystems but are often not represented on food chains



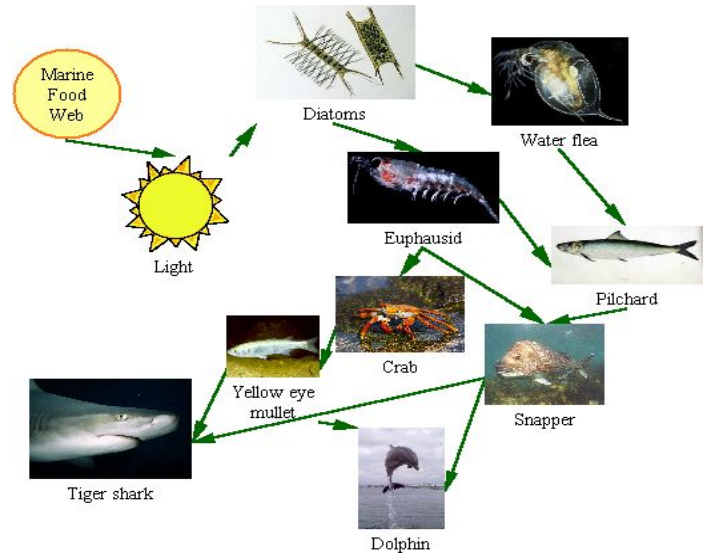
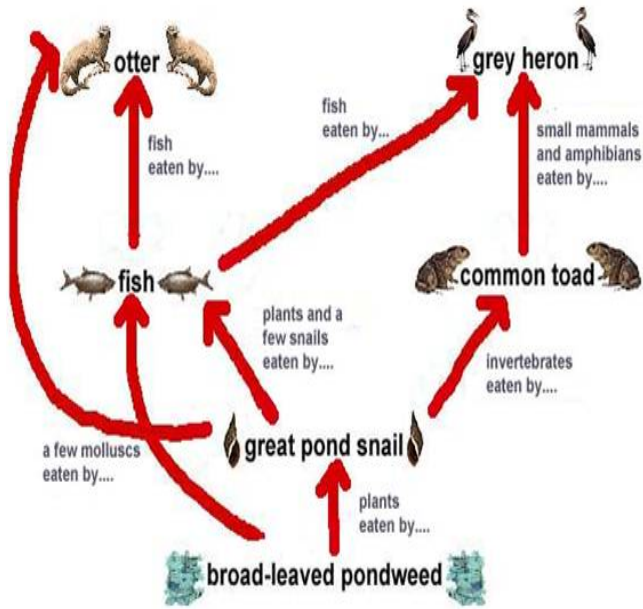


## Food Chains

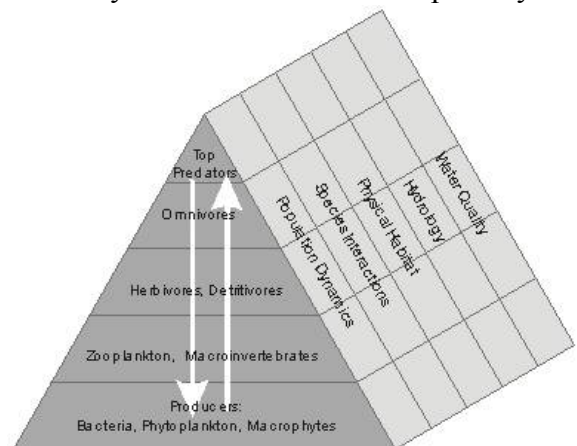
- **Producer**
- **1<sup>st</sup> order Consumer or Herbivore**
- **2<sup>nd</sup> order Consumer or 1<sup>st</sup> order Carnivore**
- **3<sup>rd</sup> order Consumer or 2<sup>nd</sup> order Carnivore**
- **4<sup>th</sup> order Consumer or 3<sup>rd</sup> order Carnivore**
- **Decomposers – consume dead and decaying matter as bacteria**



**Food Web** – many food chains in relation to each other



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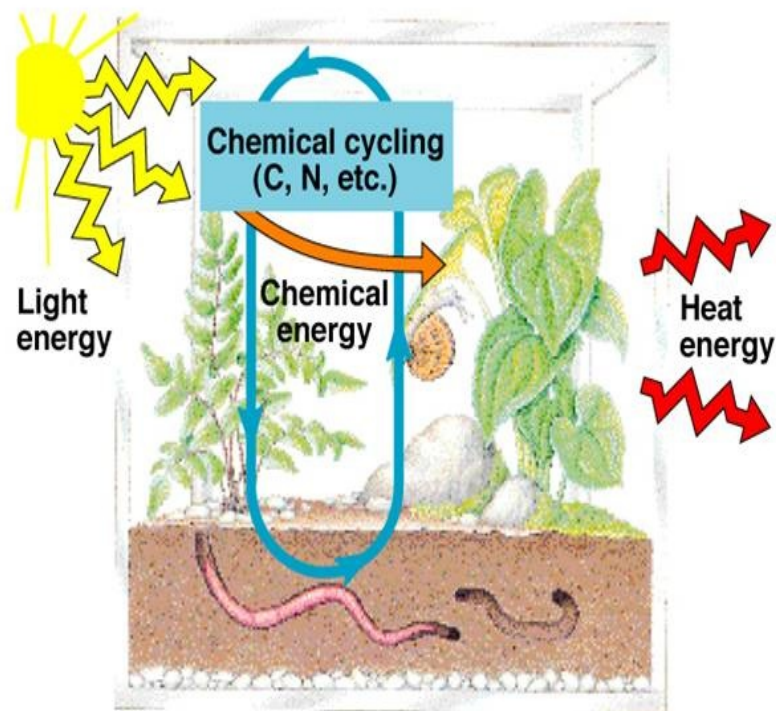


## Energy flow through ecosystems

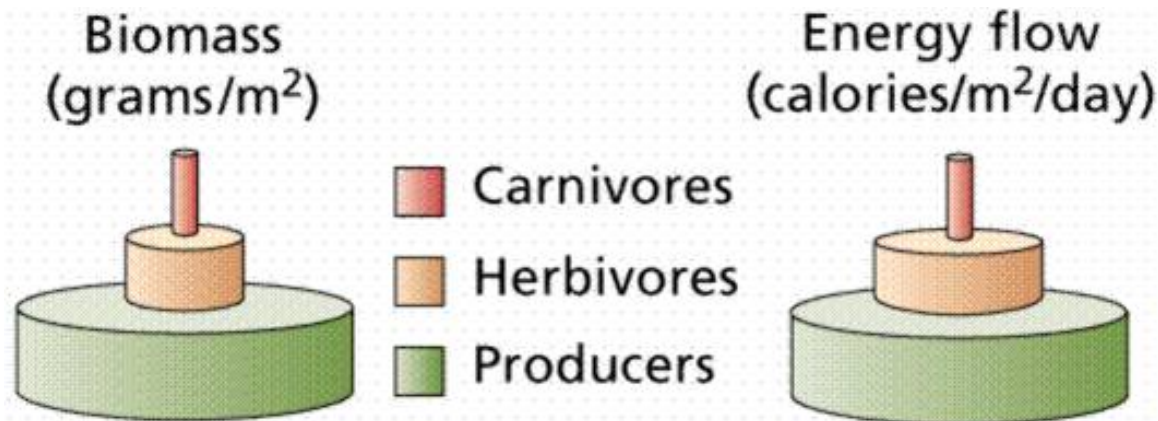
- **Gross primary productivity** = the rate at which the primary producers capture and store energy per unit time since the primary producers expend energy during respiration the **net primary productivity** is considerably lower than the gross productivity
- Productivity is usually measured as biomass (dry weight of organic matter) per unit area per a specified time interval, e.g.  $kg/m^2/yr$
- The trophic structure of an ecosystem is often represented by an **ecological pyramid**, with the primary producers at the base and the other levels above
- Most of the food eaten by organisms is converted to biomass, or used to maintain metabolic functions, or lost as heat, only about **10% of the energy** makes it to the next level
- This massive energy loss between trophic levels explains why food chains can't contain more than a few levels It takes billions of primary producers (plants) to support millions of primary consumers, which support a few secondary consumers. This is why there are so few large carnivores on earth
- An **energy pyramid** is a more useful way to depict an ecosystem's trophic structure
- Each block of the pyramid is proportional to the amount of energy it contains
- Pyramids may also represent biomass or numbers of individuals
- The energy pyramid concept helps explain the phenomenon of **biological magnification** - the tendency for toxic substances to increase in concentration at progressively higher levels of the food chain

## Energy vs. Nutrients

- Nutrients are **cyclic** – biogeochemical cycles
- Energy flow is **one way**



## Biomass and Energy Pyramids



**Ecological succession** = a directional, cumulative change in the species that occupy a given area, through time

- **Primary succession** - starts from barren ground, e.g. new islands or de-glaciated areas
- **Secondary succession** - starts from disturbed areas, e.g. abandoned farm land or storm ravaged land
- Succession starts with a **pioneer community**, the first organisms to occupy an area
- Several **transitional communities** may come and go
- A **climax community**, a stable, self-perpetuating array of species in equilibrium with one another and their habitat, will form.

**Biodiversity** - Biodiversity, the number of different species within an area, is greatest in tropical areas near the equator and it decreases towards the poles

- Tropical areas have more sunlight and of greater intensity, more rainfall and longer growing seasons for plants
- This environment is quite stable and contains many vertical "layers" which provide more microhabitats
- These areas can support more species, e.g. the number of bird species is directly correlated with latitude

### Weather and climate

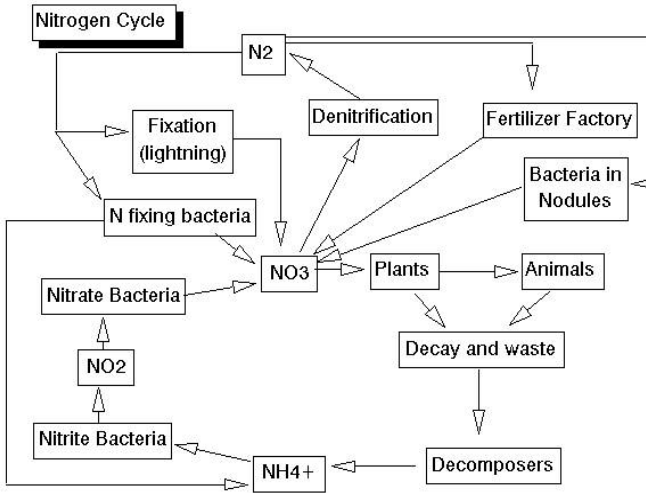
- **Biome** = a large region of land characterized by the climax vegetation of the ecosystems within its boundaries
- The distribution and key features of biomes are the outcome of temperatures, soils and moisture levels (which vary with latitude and altitude), and evolutionary history
- **Weather** = the condition of the atmosphere at any given time
- **Climate** = the accumulation of weather events over a long period of time (temperatures, humidity, wind, cloud cover, rainfall)
- Climate is dependent upon several factors:
  - Solar radiation
  - The earth's daily rotation
  - The earth's rotation around the sun
  - The distributions of continents and oceans

**Elevation or Depth of Light Penetration** Heat energy from the **sun** drives the earth's weather systems, which ultimately determine the composition of ecosystems

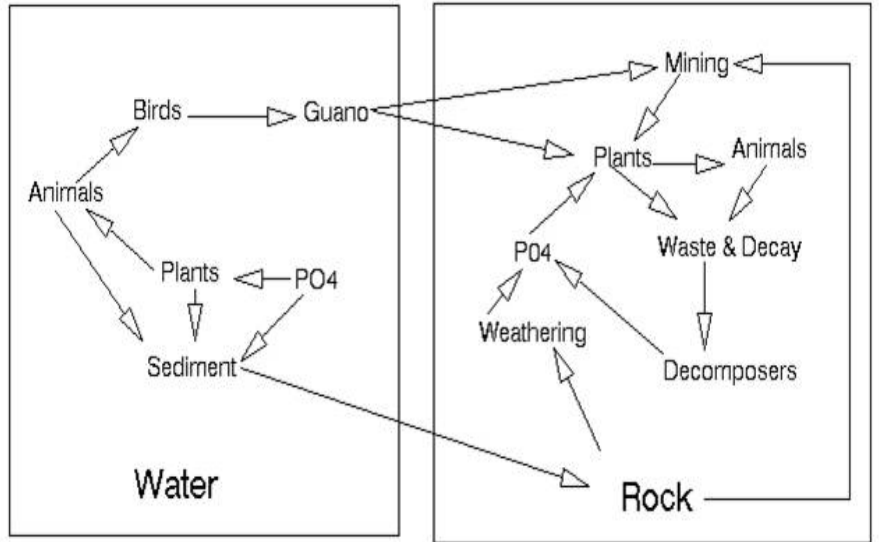


In aquatic environments it is often the depth of light penetration that is the key factor.

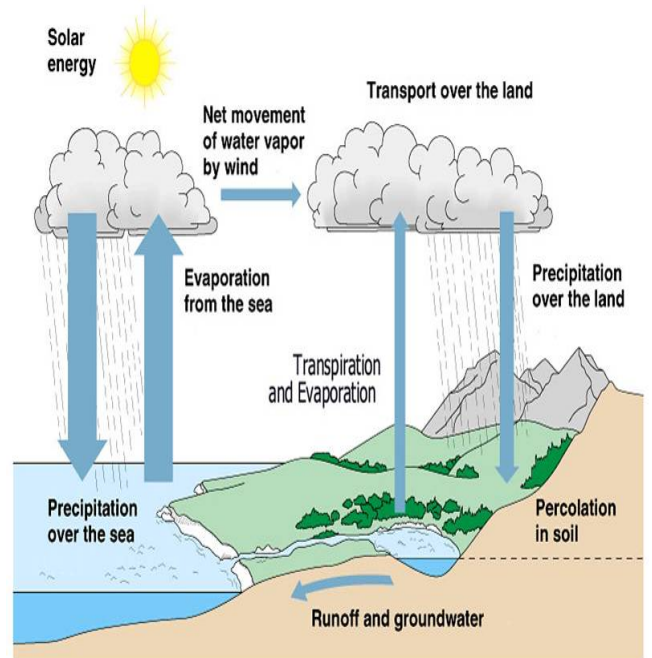
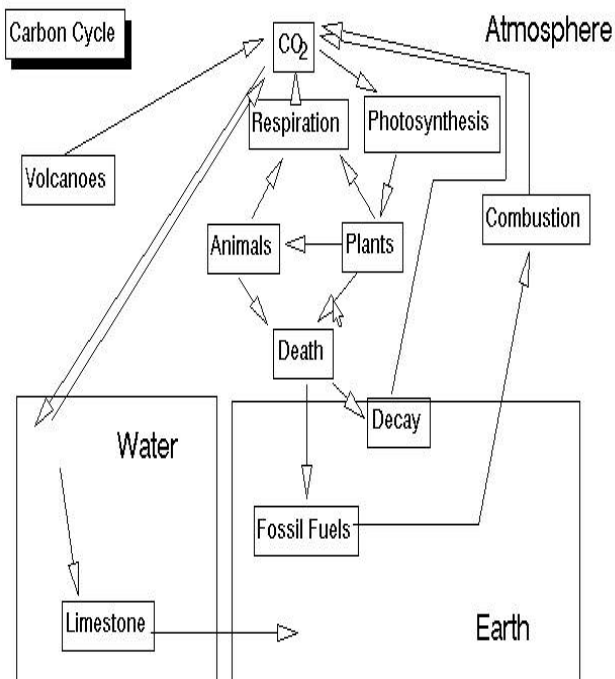
**Nutrient Recycling – Biogeochemical Cycles**



**Phosphorus Cycle**



**Hydrologic (Water) Cycle**





## Watershed

A **watershed or drainage basin** is an area of land where water from rain and melting snow or ice drains downhill into a body of water, such as a river, lake, reservoir, wetland. All of the major terrestrial and aquatic ecosystems are impacted by what happens in a watershed.



The rivers will eventually flow into large rivers which become estuaries and flow into the oceans.

- Watershed surface water management plans are implemented to reduce flooding, improve water quality, and enhance stream and wetland habitat.
- Land usage and water treatment methods are important in maintaining water quality in the watershed
- Sources of water pollution may include **point source pollution** from a clearly identifiable location or **nonpoint source pollution** that comes from many different places.
- Sources of pollution usually fall into four main categories – industrial, residential, commercial, and environmental
- Some types of pollution may include
  - **organic pollution** – decomposition of living organisms and their bi-products
  - **inorganic pollution** – dissolved and suspended solids as silt, salts, and minerals
  - **toxic pollution** – heavy metals and other chemical compounds that are lethal to organisms
  - **thermal pollution** – waste heat from industrial and power generation processes