KANSAS MASTER NATURALIST PROGRAM

General Ecology

Chapter Goals

After completing this unit volunteers should be able to:

- Understand the definition of "ecology" and be able to define specific-sized systems.
- Understand the ecosystem characteristics that influence the distribution of life on Earth.
- Understand the flow of energy and the cycling of nutrients throughout a system.
- Describe the hydrologic cycle, the nitrogen cycle, and the carbon cycle.
- Explain what is meant by succession and climax and list the factors responsible for each.
- Illustrate a food web and explain the importance of trophic relationships.
- Define biodiversity and understand the importance of managing for biodiversity.

A. Defining Ecology

The term "ecology" is derived from the Greek words, *oikos*, for home, and *logos,* which refers to "the study of" some particular topic. Literally translated then, **ecology means the study of the home**.

When we try to pick out anything by itself, we find it hitched to everything else in the universe.
-John Muir

Modern definitions for ecology focus on the key importance of *relationships* and *interactions.* "Ecology is the study of the relationships of organisms to their environment and to one another" (Brewer, 1994).

The typical study of ecology involves exploring the relationships between the living (biotic) and the non-living (abiotic) components of a system.

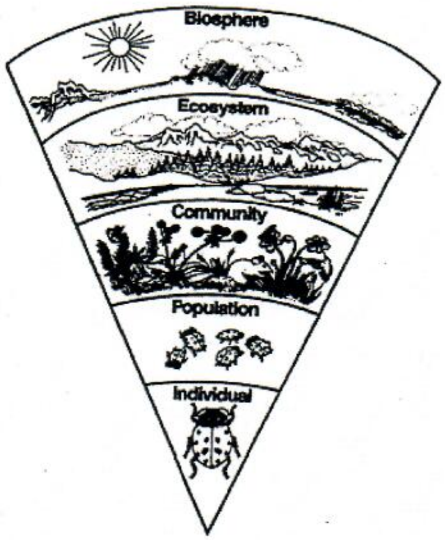
Some examples of **biotic** components = bacteria, fungi, algae, plants, and animals.

Some examples of **abiotic** components = temperature, wind, precipitation, elements found in the soil and atomosphere.

Ecologists study systems and they can be large or small or any size in between. It can be a single organism or the entire planet Earth.

B. Levels of Biotic Organization - Systems

- There is a wide variety of system sizes. To understand and compare there must be standards for defining different-sized systems:



- ***Individual*** – single organism of a specific species. Example: Prairie dog
- ***Population*** – A group of the same species occupying a particular area at the same time. Example: Prairie dog colony
- ***Community*** – Populations of different species that occur in a similar place and interact. Example: Prairie dogs, snakes, spiders, coyotes, burrowing owls all living in a prairie dog town.
- ***Ecosystem*** – A broad area defined by similar vegetation and climate. Example: The Flint Hills.
- ***Biome*** – A very broad area defined by dominant vegetation. Example: Grassland.
- ***Biosphere*** –The outer shell of the earth and its atmosphere where life occurs.

You are perhaps familiar with the concept of an "ecosystem" within a drop of pond water. While it would be erroneous to think that the numerous organisms you might find in such a drop would be self-sustaining over any length of time it is nevertheless true that functioning communities, ecosystems and landscapes can be found within small confines, including individual organisms!

Two commonly used terms with which you will become familiar are **niche** and **habitat**.

Niche = its "occupation" or ecological role in the community. Important aspects include which species it relies on for food and which species prey on it. Ecologists more broadly define the niche of a species as the sum total of all its interactions within a given community.

Habitat = is the address or home of the organism. It is the place where a plant or animal normally lives, and is often characterized by a dominant plant form or physical characteristic. For example, short-grass prairie is the habitat for prairie dogs while fast moving streams are the habitat for fish known as darters.

For an organism to survive, habitat must provide:

1. Food
2. Water
3. Shelter

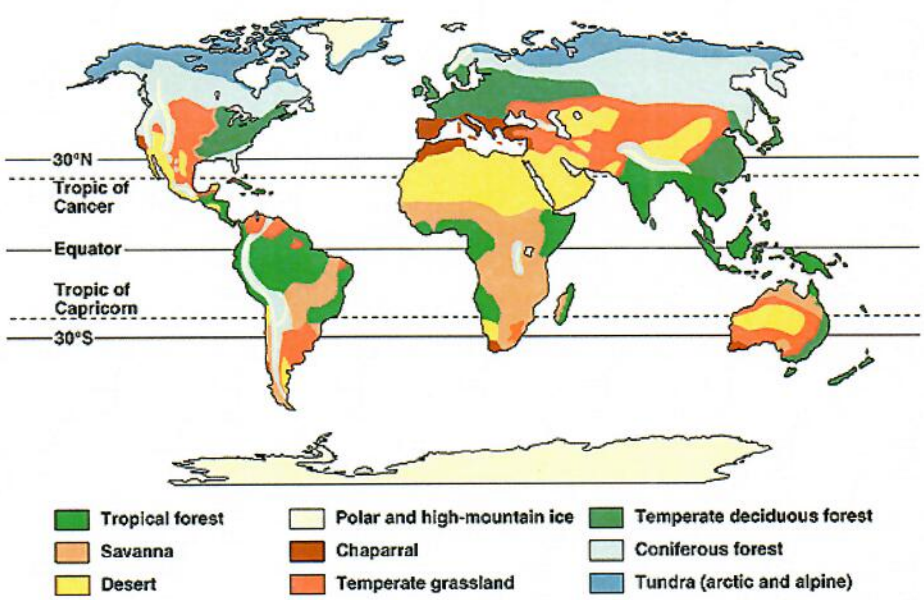
In order for a habitat to be suitable, however, these three resources must be easily accessible. If water was located at too great a distance from food and shelter, for instance, a particular species might not find that habitat acceptable. Space is yet another important component of habitat. Beyond the fact that most species have minimal home range requirements, the amount of area necessary to provide all necessary resources for survival, many are also territorial, defending their space from being utilized by others of their own species. Thus habitat must provide each species with easily accessible food, shelter and water within a space large enough to secure those resources for the individual or social group.

C. Ecosystem Characteristics

During your Master Naturalist training, you will be introduced to a number of ecosystems distinct to your region. We want you to become better acquainted with both the structure and functioning of those systems, and the ways in which each major component of the system interacts and depends on the rest to maintain the overall health of that systeEarly ecologists soon became aware of the fact that regardless of where they were, be it arctic tundra, prairie grassland, tropical rain forest, or coral reef, there were a number of underlying principles and relationships which seemed to provide a foundation for the understanding of all ecological systems.

1. Climate and Weather

Climate is defined as the long-term patterns of temperature, precipitation, wind and humidity that exist for a given area. Short-term changes in these atmospheric conditions are referred to as **weather**. On a large geographic scale, it is interesting to note that the world's major terrestrial ecosystems, **biomes**, can be delineated almost entirely on the basis of mean annual temperature and precipitation. Not unexpectedly, Tropical Rain Forests are found where both average annual precipitation and average annual temperature are high. Perhaps less expected is the fact that both Deserts and Tundra are characterized by very low average precipitation.



World Biomes

The plants and animals that comprise the biotic component of a given biome often exhibit unique adaptations that are reflective of their abiotic environment. For example, think of three features of desert plants (such as cacti) that have evolved in response to arid conditions. What adaptations do desert animals exhibit? Plants and animals that are not closely related often exhibit similar adaptations to similar environmental conditions. This is known as **convergent evolution**.

2. Sunlight and Heat

Heat and light received from the sun, collectively known as **solar radiation,** do not reach all parts of the Earth in equal amounts or for equal lengths of time. Heat and light vary in intensity, during the course of a day as the Earth rotates on its axis, and throughout the year as it revolves in an orbit around the sun.

Polar regions receive much less solar radiation than do tropical regions because the sun is farther from the poles than from the equator, and because of the Earth's tilt on its axis. This tilt prevents direct sunlight from reaching the poles for long periods each year.

As a result of the daily, seasonal, and annual distributions of solar radiation, we assign the Earth specific **climatic zones**-ranging from polar to temperate to tropic-which relate primarily to temperature differences. We measure solar heat, as a form of energy, in degrees of relative warmth called **temperature**. Plants and animals tolerate certain high and low limits of temperature. Beyond those limits, each organism cannot survive. Temperature also influences rate of reproduction, growth, and survival of living things. For example, in a temperate climate, persistent cold weather late into the spring, prevents most plants from developing properly, as well as the insects and rodents that feed upon them. A poor supply of insects and rodents then decreases the well-being of hawks, foxes, and other animals. Therefore, temperature – as a component of weather – influences the strengths or weaknesses of food chains and webs.

Frogs are ectotherms, animals that cannot generate or control their own body heat.

Squirrels are endotherms, warm-blooded mammals that can generate and maintain their own body heat.

Endotherms, such as birds and mammals, have insulated bodies that regulate internal temperatures regardless of the amount of heat in their environments.

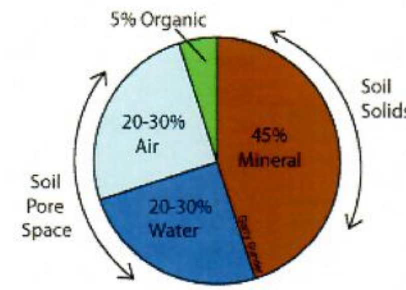
Ectotherms, such as reptiles, fishes, amphibians, and insects, cannot generate or maintain their own body heat so, their bodies usually assume the same temperature as their environments.

The amount of moisture in the air, known as **humidity**, influences the tolerance of most animals to external temperature extremes. Hot or cold temperatures in dry climates generally are easier for most animals to cope with than similar extremes in wet climates.

3. Soil

Soil is the Earth's loose surface material in which most plants are rooted. In large measure the quality and abundance of life in any region is a reflection of its soil's characteristics. More than just "dirt," soil is itself a complex ecosystem.

Soil Composition by Volume

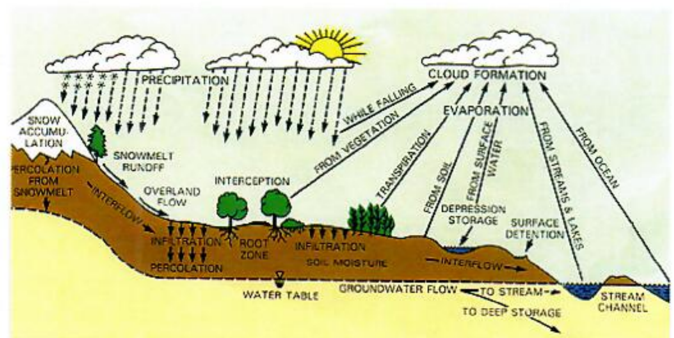


Soil =

- Inorganic minerals (small pieces of rock)
- Organic material (originated from living organisms, includes leaf litter and decomposing material)
- Water (and anything dissolved in the water)
- Gasses/air
- Living organisms (worms, insects, etc…)

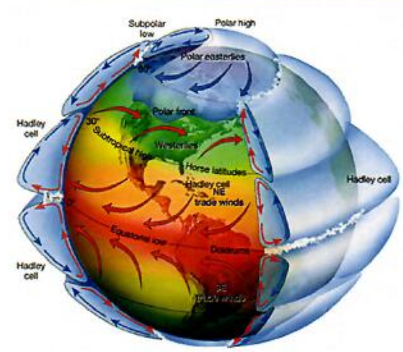
The development of a mature soil may take hundreds of years to complete through the complex interactions of climate, parent material (bedrock), topography and organisms. If you lose the soil, you lose the ability to grow plants and feed animals – ask anyone who lived through the Dust Bowl years!

4. Water



Water takes many forms in the environment: water vapor is a gas; standing water is a liquid; and frozen water or ice is a solid. In the atmosphere, water is humidity. We call water precipitation when it falls to the ground as snow, sleet, rain, or hail. In oceans, lakes, and streams, we call it surface water; and it is part of every living cell.

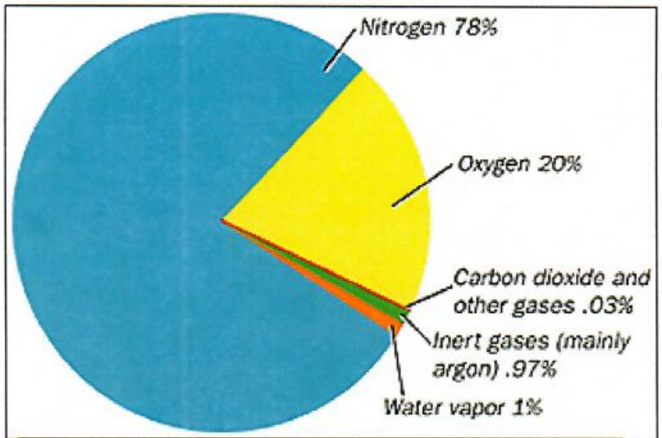
No matter where or in what form it occurs, water eventually recycles through processes of evaporation from streams, lakes, and oceans; transpiration from plants: and respiration from animals. This is called the hydrologic, or water, cycle.



The sun drives the movement of water and air over the surface of our planet. Differential heating of the atmosphere, based on latitude and season, sets in motion generally recognized global wind patterns which circulate both heat and water. Together with topography, these atmospheric movements play a dominant role in determining the location of the Earth's major biomes, as well as the regional availability of water.

5. Air

While we sometimes use the words "air" and "oxygen" interchangeably, our atmosphere is actually 78% nitrogen and only 20% oxygen. The remaining 1% is comprised primarily of carbon dioxide, CO_2 and water vapor.



Air is comprised of a variety of gases. Each is important to allowing Earth to support life. *Image courtesy of USGS.*

These two gases are very important in creating the "greenhouse effect." By absorbing much of the sun's infrared radiation, these gases trap the sun's heat and act as the Earth's warming blanket. Without them, our planet would be uninhabitable, much like our moon or the planet Mars. Scientists are concerned that our present rate of fossil fuel consumption will raise atmospheric levels of carbon dioxide enough to significantly increase global temperatures over the next 50-100 years. If this were to occur, it would have profound effects on both the distribution and survival of many species, including our own!

Oxygen, given off by plants and other sources, is taken in by animals through lungs, gills, and other specialized breathing mechanisms. Animals transport oxygen in their blood to many cells of the body, to be used for every life-support process.

At high elevations, air contains less oxygen, so animals' hearts must pump harder to get blood and, therefore, oxygen to all parts of their bodies. Animals must adapt to different conditions of the air, move to a different environment, or perish. For example, animals living at high altitudes have larger hearts than do their relatives at lower elevations.

Unlike water in oceans, which is nearly incompressible and weighs the same at the ocean floor as it does at the surface; air at sea level weighs more than air at the top of mountains. Although there is air in our atmosphere hundreds of miles above the Earth, more than one-half of our breathable air stays within 3 ½ miles of Earth's surface. Because air is highly compressible, air at or near the Earth's surface is much heavier, and less stable than air higher up. This condition determines weather changes. Therefore, air pressure refers to the density of air at a given time in a given place.

D. The Hydrological Cycle

The continuous process involving the circulation of water between the atmosphere, the ocean and the land is called the hydrologic, or water, cycle. Solar radiation and gravity are the driving forces that "run" the cycle.

Approximately 97% of the total water on Earth is in the oceans and seas, and most of the remainder is locked in glaciers, snow, and ice. The remainder, the inland waters of lakes, rivers, and wetlands, constitutes only about 0.3% of the total.

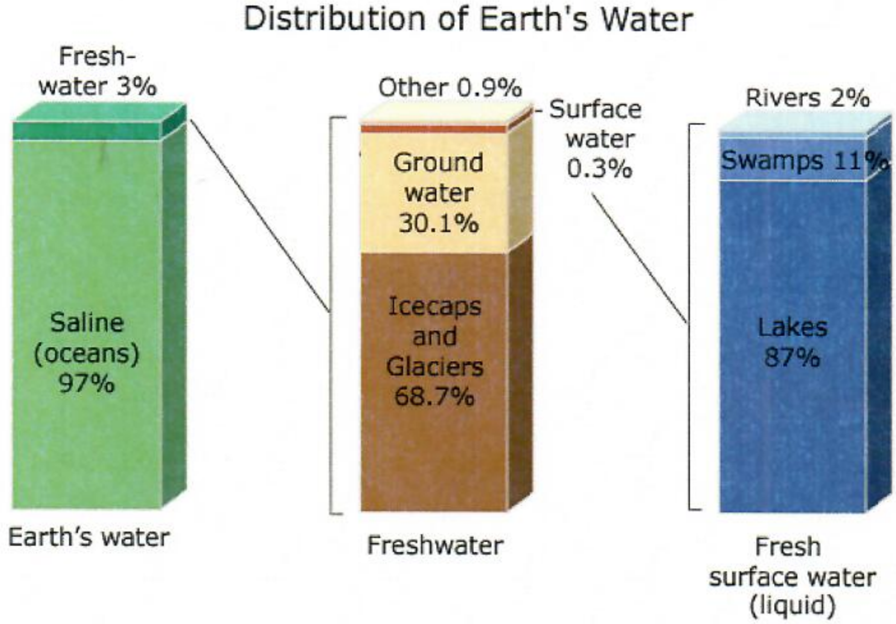
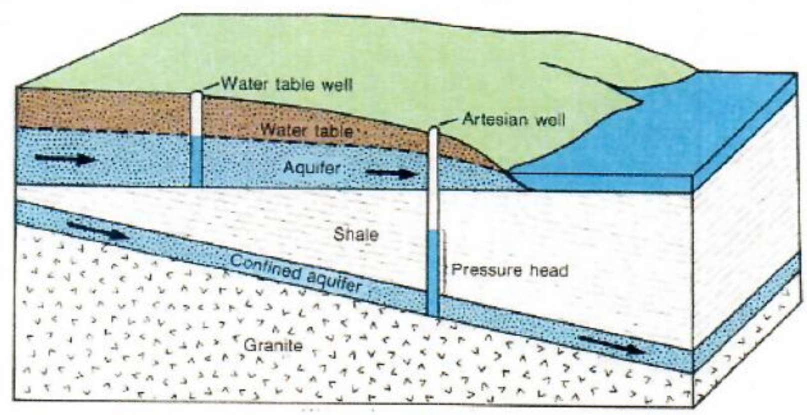


Image courtesy of USGS.

Water that percolates through the soil may eventually reach an impermeable layer and reside there as groundwater. Its upper surface is referred to as the water table. Geological formations that yield water in usable (in human terms) quantities are referred to as **aquifers**.



Implications for Management

There is a popular saying: "Everybody talks about the weather, but nobody ever does anything about it." Despite our best efforts to bring needed rains through chanting, dancing, or seeding clouds, we have had limited success in changing, or even predicting short-term weather. Our discussion of the implications for management of the hydrological cycle is therefore going to focus on the management of water (aquatic systems) once it's on the ground. How we manage aquatic systems is based on the values we assign to them. Some of those values might include flood storage and conveyance, water supply, pollution and sediment control, recreation, aquifer recharge and fish and wildlife habitat.

1. Control Erosion

All aquatic systems are affected by the status of the terrestrial systems that surround them. Controlling erosion throughout the watershed is of primary importance to maintaining the health of aquatic systems.

- Improve groundwater infiltration by reducing the amount of impervious surfaces
- Increase the use of deep-rooted native species of grasses and wildflower surrounding urban or agricultural lands to reduce pollution runoff.
- Restoration of native aquatic plants (including submerged, emergent and shoreline species) can improve infiltration, reduce erosion, and filter out many harmful pollutants, while increasing habitat for fish and wildlife.

2. Control Water Levels

Controlling water levels is another management tool that can improve the value of aquatic systems, particularly those involving constructed wetlands.

- Reducing water levels creates mudflats that are attractive to a variety of birds and allows for improved soil aeration and growth of new food-producing plants. Such "draw downs" are frequently performed in the fall to provide migratory birds with critical food resources along their routes.
- Increasing water levels simulates flood conditions, bringing in additional nutrients and stimulating aquatic plant growth.

E. Energy flow and Nutrient Cycling

Cells make up all of life and each living cell is a miniature factory that needs new supplies to make molecules and energy to run the operations.

Energy Flow

Energy to fuel the operations of a cell comes from the breaking down of food molecules – typically carbohydrates. When the chemical bonds that hold carbon and hydrogen together are broken, energy is released. This energy can be harvested to fuel the work of the cell.

Cells can obtain their carbohydrate "food" in two different ways:

1. They can make their own food using the energy of the sun = **autotrophic**
   (*auto* = self; *troph* = feeding)
2. They can eat their food = **hetertrophic**
   (*hetero* = different; *troph* = feeding)

Autotrophic organisms typically use the process of photosynthesis to make their food. Photosynthesis captures the energy from the sun in pigment (chlorophyll in the leaves of plants) and transfers that energy into new chemical bonds to form carbohydrates. Therefore, plants can make their own food as long as they are exposed to the sun. One thing to keep in mind: not all of the cells of a plant are photosynthetic. Cells in the root of plants can't do

photosynthesis but they still need to have food to fuel cellular operations. Plants need to be able to transfer the food made in the leaves down to other parts of the plant.

Living organisms are built out of organic molecules. Organic = molecules based on the element **carbon**. There are four basic groups of organic molecules that compose and operate living organisms:

1. Carbohydrates (made out of C, H, O)
2. Lipids (made out of C, H, O)
3. Proteins (made out of C, H, O, N)
4. Nucleic Acids (made out of C, H, O, N, P)

The ultimate source of energy in any system is the sun. Plants and other photosynthetic organisms (e.g. algae and pigmented bacteria) are the foundation of any system and put the sun's energy into organic molecules thus making the energy available to heterotrophic forms of life. However, you can't recycle the sun's energy. It is a one-way flow through a system and it is eventually lost in the form of heat. You can recycle elements – in fact, elements are re-used over and over.

Note:

- Energy flows through a system
- Nutrients cycle within a system and are continually recycled

There are approximately 20 different elements that are important to life but 96% of living organisms are composed of Carbon/C, Hydrogen/H, Oxygen/O, Nitrogen/N, Phosphorous/P, and Sulfur/S. Elements move freely between the abiotic and biotic portions of an ecosystem as plants take in carbon dioxide from the air, and water and minerals from the soil to produce carbohydrates, fats and proteins. They are then passed along the food chain to both herbivores and carnivores. Nutrients are eventually returned to their elemental form and again take up residency in the abiotic environment upon decomposition of both excretory waste and dead plant and animal tissue.

Some elements that currently (and temporarily) make up your body may well have resided in a dinosaur a hundred million years ago, or in the primordial bacteria that first colonized the planet almost 4 billion years ago.

Nutrient Cycles

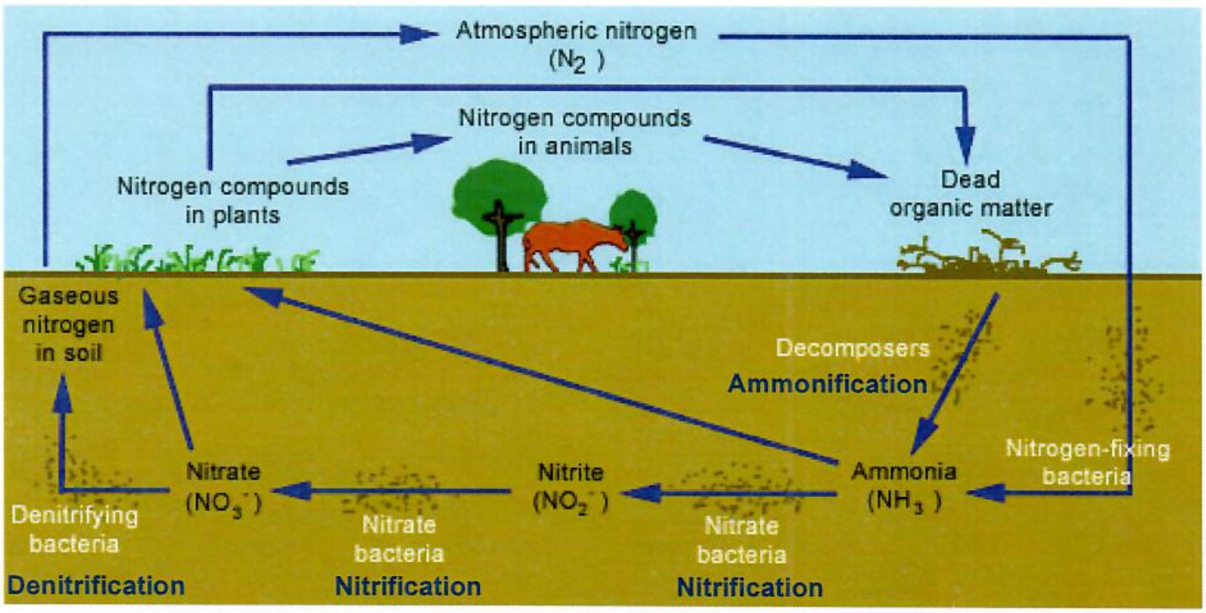
Nutrient cycles are more formally referred to as biogeochemical cycles. It emphasizes the fact that the biological (bio) realm and the rest of the earth (geo) are inextricably interconnected through the movement of essential chemical elements. Biogeochemical cycles have no starting point.

Of the many existing biochemical cycles, those most frequently detailed include the cycling of carbon, nitrogen, phosphorus and sulfur. Common to all are the presence of either a gaseous or sedimentary reservoir, and a change in the chemical nature of the element as it passes from one step to the next. We will examine the nitrogen cycle in more detail. Those

wishing to learn more about the cycling of other nutrients are encouraged to do so by consulting any ecology textbook or online.

The Nitrogen Cycle

Nitrogen is the building block of all plant and animal proteins. The earth's atmosphere, which is 79% nitrogen, is the vast reservoir for this important nutrient. Plants can only take up nitrogen as either ammonia (NH_3) or nitrate (NO_3), so even though life is bathed in nitrogen, it cannot use any of it unless it is first "fixed" or changed from the N_2 form to either NH_3 or NO_3.



The Nitrogen Cycle. Bacteria are the key drivers of the Nitrogen Cycle. Through nitrogen-fixing, nitrification, denitrification and ammonification nitrogen is converted between it's various chemical forms. This allows nitrogen to be in usable forms for plant and animal life.

Biological Process that Convert Nitrogen in a Living System:

1. Nitrogen Fixation = converting N_2 to ammonia (NH_3).

Rhizobium bacteria can take atmospheric N_2 and convert it to NH_3 – a form of nitrogen that plants can utilize to make proteins. In many terrestrial environments, leguminous plants (members of the pea and bean family) often harbor the bacterium, *Rhizobium*, in root nodules. This is a symbiotic arrangement; that is both organisms benefit from the relationship. The bacteria tap into the plant's stored food, while the legume benefits by getting excess of ammonia produced beyond the needs of the bacteria – this ammonia is a source of nitrogen the plant can use to make proteins. This is why legumes are often high in protein. It is also why legumes like vetch, clover and alfalfa are often planted as cover crops.

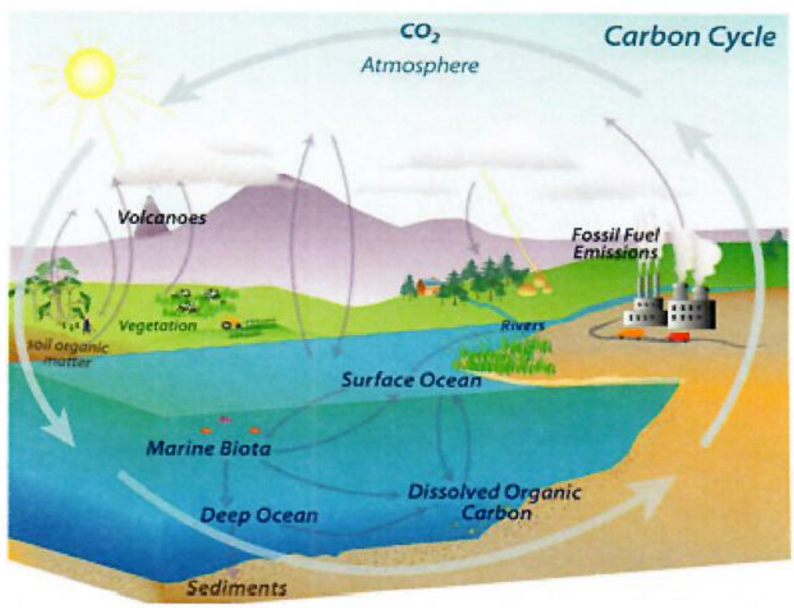
Rhizobium bacteria in the roots of legumes can add 250 pounds of nitrogen compounds to each acre planted.

2. Ammonification = making NH_3 (ammonia) from the breakdown of proteins
Animals and decomposers produce their proteins from the plant or animal proteins in their diet. When these proteins are broken down in respiration, a waste product, ammonia, is produced. Ammonia can be directly used by plants without any chemical changes. However, ammonia is highly gaseous (high vapor pressure) and will vaporize quickly from a surface.

Ammonia may be voided directly (fish) or it may first be converted to a less toxic form. Most mammals, humans included, convert it to urea, while most birds, reptiles and invertebrates convert it to a more solid form, uric acid. These compounds are the source of energy for another group of bacteria, which convert the nitrogen compounds to ammonia in a process known as ammonification. Upon death, this same process will break down an organism's body proteins.

3. Nitrification = converts NH_3 (ammonia) to NO_2 (nitrite) or NO_3 (nitrate)
Bacteria can change ammonia NH3 into salts that will stay in the soil longer than the gaseous ammonia. Nitrite and nitrate will bond to soil particles and stay within the soil and add a level of fertility to the soil. These salts will dissolve in water and be taken up by plant roots after a rain, thus providing plants with a source of nitrogen.

4. Denitrification = converts NO_2 (nitrite) or NO_3 (nitrate) back to N_2
Soils that have been compacted, waterlogged, or are otherwise anerobic (without oxygen), will often set the stage for a loss of utilizable nitrogen in soils. Yet another group of bacteria, all anaerobes, will obtain significant energy by converting nitrate or nitrite back to elemental nitrogen, N_2. Although this may be looked at by some as a "negative" or harmful process (well-aerated soils are more productive), denitrification does bring the nitrogen cycle full circle, insuring that atmospheric concentrations of nitrogen are maintained and that the system as a whole remains in balance.



The Carbon Cycle

The Carbon Cycle, the biogeochemical cycle where carbon moves between organisms and the atmosphere through the processes of photosynthesis and respiration. Image courtesy of EPA

As all good Trekkies know, we here on Earth are carbon-based life forms.

Carbon is not only one of the major building blocks of all life (known to date), but it is inextricably bound to the way most all organisms obtain their energy.

Plants take in carbon dioxide (CO_2) and water, and through the process of photosynthesis, create glucose, a simple carbohydrate or sugar.

Simple sugars, the most basic form of food energy, can be further modified to form complex carbohydrates (starches), various fats and oils, and proteins. Plants use some of these organic compounds for their own metabolic needs, thereby returning some carbon back to the environment as CO_2, but most is retained in the plant body.

Herbivores (plant eaters) obtain their carbon from the plants they eat and **carnivores** from the animals they eat. Decomposers obtain their carbon from the dead plants and animals they consume. Ultimately, all consumers and decomposers return most of the carbon back to the atmosphere (or water) as CO_2 in the process of respiration, thus making it available once again to plants.

That is the simple part of the cycle. The more interesting part has to do with the amount of carbon that *is not* returned to the system as gaseous CO_2. Organic matter that escapes immediate decomposition may enter long-term storage as fossil carbon. This does not happen to any appreciable degree today, but vast quantities of carbon entered this long-term storage 285-350 million years ago during the Carboniferous Period. This carbon is now being returned to the environment as CO_2 at the rate of about 7 billion tons per year in the process of burning our fossil fuels; coal, oil and gas. About half that amount seems to be accumulating in the atmosphere. An estimated one to two billion tons is being absorbed by oceans and the remaining amount has most likely gone into increased plant biomass.

Oceans are actually the single largest reservoir for CO_2, storing 60% more than the atmosphere. When CO_2 dissolves in water, some of it forms carbonic acid that, in turn, may form various carbonates and bicarbonates. Because they are not very soluble, carbonates usually precipitate out and form sediments. One of the most common examples that everyone is familiar with is calcium carbonate or limestone.

Climate Change

Most everyone has heard of the greenhouse effect and global warming. The greenhouse effect refers to the fact that gases (most prominently CO_2) in our upper atmosphere (troposphere) trap and hold radiant heat, much like the glass in a greenhouse. Increasing the concentration of greenhouse gases increases this heat retention. The vast majority of climatologists are now convinced that human activity, primarily the burning of fossil fuels, is directly responsible for the significant increases in greenhouse gas concentrations measured over the last 50 years. If this trend continues, CO_2 levels could double by 2050, leading to a possible increase in global average temperature between 3.5-9° F.

The implications of such a temperature increase, at a rate 10-100 times faster than has occurred during the past 10,000 year, are profound. Hotter, drier conditions will negatively impact food production and water resources, increase the frequency and severity of storms and hurricanes, raise sea levels 2-3 feet (flooding coastal communities) and have a severe impact on most plant and animal communities. If, for example, CO_2 levels do double by 2050, hardwood trees (and the entire assemblage of hardwood forest species) east of the Mississippi would have to shift 300 miles northward to find suitable climatological conditions. Plants and animals can, of course, shift their distributions in response to climate change, but following the retreat of the last ice age northward movement of hardwood trees was only 12 miles per 100 years. The implication is that many members of those forest communities will simply not survive.

As severe as these outcomes are, there is concern that rising temperatures may set in motion a dangerous positive feedback, or "runaway greenhouse," effect. We mentioned that the oceans serve as an important reservoir or sink for carbon dioxide. However, as global temperatures rise, the ocean's ability to dissolve and hold CO_2 falls. Release of this oceanic CO_2 into the atmosphere will further accelerate the rate of change.

Likewise, increasing temperatures on land will melt continental ice sheets, adding to rising ocean levels and exposing more dark, heat absorbing landmass. It will also speed up decomposition rates, resulting in the release of even more CO_2. Lastly, the continued destruction and burning of tropical forests exacerbates the problem two-fold. First, deforestation directly contributes about one-fifth of the annual release of carbon dioxide, and second, loss of these trees removes their ability to absorb excess CO_2.

To at least partially offset rising CO_2 production, many countries have embarked on significant reforestation programs. Most experts agree, however, that significant reduction in the threat of global warming will not come without significant reduction in our use of fossil fuels. We need to greatly increase the efficiency with which we continue to use coal, oil and natural gas and switch as soon as possible to alternative, renewable energy sources.

F. Ecological Succession

One of the overarching themes to your Master Naturalist training should be the fact that nature is dynamic. The natural world is constantly undergoing change. Everyone living in Kansas is familiar with the phrase, "If you don't like the weather, stick around a few minutes, it's bound to change." We can all relate to the fact that not only is our weather unpredictable on a day-to-day basis, but that even seasonal patterns vary from year to year. Weather is just one of many factors that are subject to change within any organism's environment. Changes in the distribution and abundance of species may be in response to changes in either short or long-term weather patterns, other species, random events, human disturbance, or ecological succession.

Succession = the process by which gradual changes occur in the composition of species making up a community or ecosystem.

Primary Succession = the development of biotic communities in an area with no true soil e.g. lichens growing on a rock or plants growing on a cooled lava.

Pioneer species = hardy new species that are the first to live in an area previously devoid of life e.g. lichens

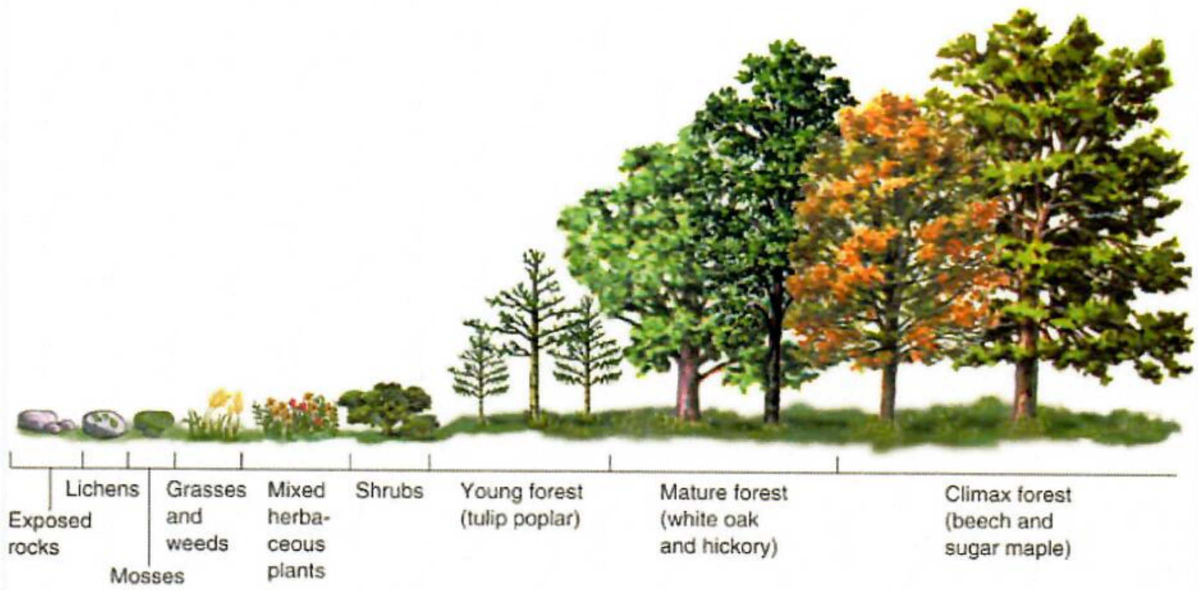
Secondary Succession = sequential development of communities in an area in which natural vegetation has been removed or destroyed but the soil is not destroyed, e.g. plant growth after a fire.

Climax Community = fairly stable, self-sustaining community in an advanced stage of ecological succession. It usually has a diverse array of species and ecological niches, it uses energy and nutrients more efficiently than simpler, immature communities.

Disturbance = a temporary change in average environmental conditions that causes a pronounced change in an ecosystem, e.g. a flood, or introduction of an exotic species.

Primary Succession

Primary succession may take hundreds, or thousands, of years before a stable climax community is attained. Much of that time may be involved in the creation of a soil substrate substantial enough to support the climax plant species. Pioneer species are the first to occupy a barren site. They typically share the following characteristics: strong powers of dispersal, high reproductive rates and the ability to persist under the extreme environmental conditions often encountered at such sites. They are usually short-lived "fugitives" which can quickly establish a foothold, but are competitively inferior to species that may take longer to establish their presence. Many well-known "weed" species are good examples of such fugitive pioneers. Over time, increasing deposition of organic matter provides resources for a greater diversity of plants. Succeeding communities, known as *seres* frequently exhibit an increase in the both the number and size of species.



Primary Succession. The gradual change of the plant and animal community in an area following the creation of a new substrate is primary succession. New substrate occurs when exposed rocks are left after a glacier retreats or a volcanic lava flow.

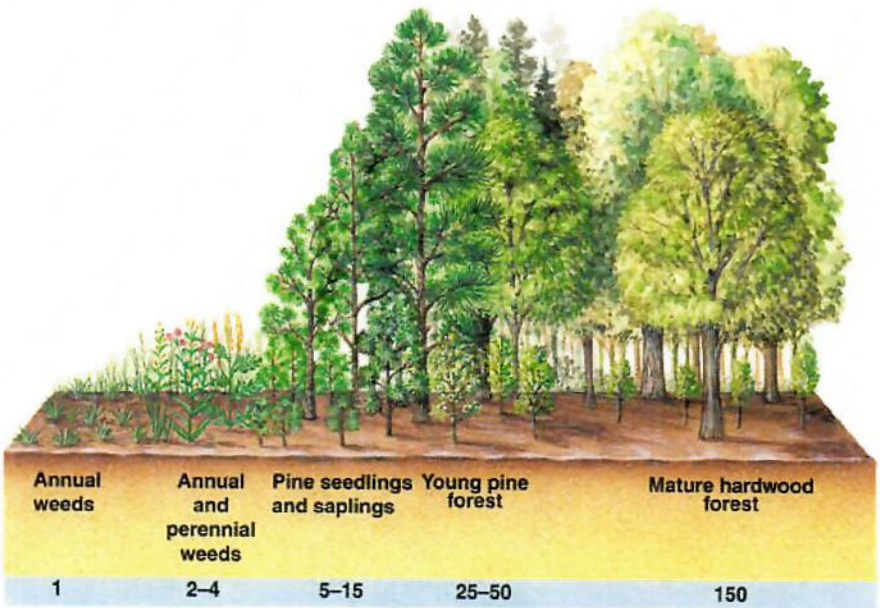
Succession was once viewed as a very orderly process whereby each sere "paved the way" for the one that followed, we now know that succession is neither so altruistic nor so predictable. While earlier plant species may make the environment more suitable for later successional species, it is equally possible that they may inhibit later species from invading or have little or no effect either way. In forest habitats, plant species replacement may be based, in part, on individual germination tolerances for light or shade or levels of soil moisture.

Ultimately, succession for any geographic region may vary considerably from site to site. Not only may it proceed along a variety of pathways, it may not always end up at the same end-point. Local conditions and chance events may produce any number of climax communities. Changes in the composition of animal species also occur over time, with animal species usually reflecting changes in the plant community. The climax community is one that is capable of self-replacement, achieving some level of steady-state stability as long as climatic patterns remain unchanged.

The predominant climax communities in Kansas are the tallgrass prairie, short grass prairie, mixed grass prairie, and the Oak hickory deciduous forest.

Secondary Succession

Disturbances that remove all or most of the members of a community often do not remove the soil substrate necessary for their existence. This soil also serves as a seed bank and will often contain viable seeds from previous communities. Thus, secondary succession may progress much more rapidly than primary succession and may skip entirely many of the earlier stages. While second-growth forests may not immediately share all of the characteristics of the forest it replaced, it may be possible to re-establish most members of a forest community within 80-100 years following a fire or other such disturbance.



Secondary Succession. When a disturbance destroys a community without destroying the soil the subsequent succession is called secondary succession. This process occurs after agricultural lands are abandoned or after a fire.

Implications for Management

> *A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.*
> -Aldo Leopold

Knowledge of succession is important in managing one of the most endangered ecosystems in the country, the tallgrass prairie. Tallgrass prairie once covered 140 million acres of North America. Today, less than 4% remains, mostly in the Kansas Flint Hills. However, we cannot save that which remains by "preserving" it. Tallgrass prairies evolved under a disturbance regimen that included both frequent fires and intense grazing by bison. We will lose our remaining prairies to succession by invasive woody species if we do not recreate these disturbances via prescribed burns and inclusion of mowing and/or grazing regimen.

G. Trophic (Feeding) Relationships

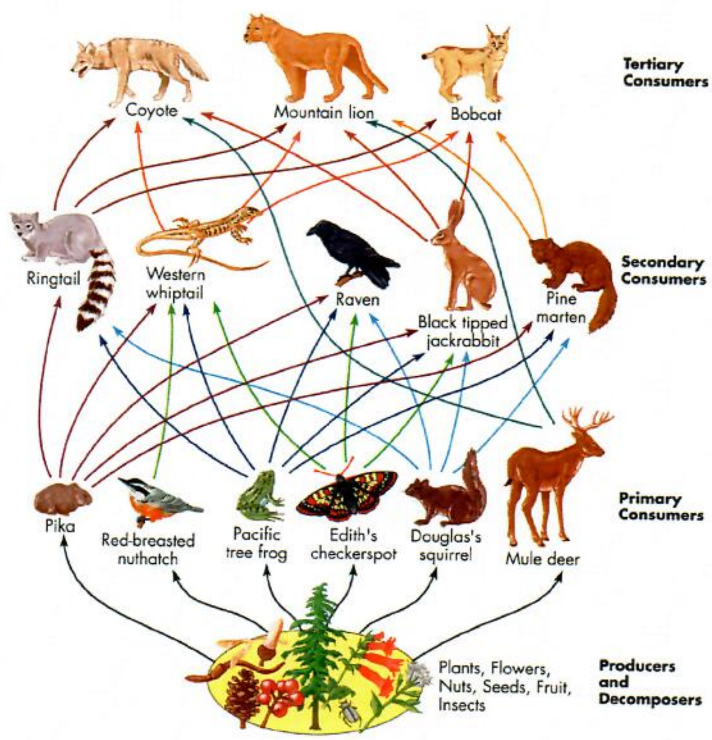
Feeding or trophic relationships defines who eats whom in order to obtain the energy and nutrients necessary for survival. Hence, any community of organisms can be organized on the basis of the following trophic levels:

- **Producers** – Those organisms capable of producing their own food, primarily by fixing energy from the sun via photosynthesis. These autotrophs (self-feeders), most of which are plants, then serve as the primary energy source for the rest of the biosphere!
- **Herbivores** – Those organisms obtaining their energy directly from plants. Also referred to as primary consumers.
- **Primary Carnivores (secondary consumers)** – Those organisms obtaining their energy from herbivores.
- **Secondary Carnivores (tertiary consumers)** – Those organisms obtaining their energy from other carnivores. While one could conceivably continue "stacking up" carnivores in this fashion indefinitely, most ecosystems rarely exceed 4 or 5 trophic levels.
- **Detritivores** – Also known as **decomposers**, these organisms obtain their food from dead plants and animals. Through their actions, the building blocks of life are returned to the environment in elemental form to be used yet again. While often not considered a distinct trophic level, they are indispensable members of the biotic community.

Food Webs

A sequence of organisms, each of which feeds on the one preceding it, forms a food chain. A local example might be: Hackberry leaf > Hackberry caterpillar > Pewee > Sharp-shinned hawk.

In most communities, several to hundreds of such food chains exist, and are interconnected in such a way as to form food web. If we included all organisms found in a system the food web would be too complex to actually draw, so most depict only a select group of organisms.



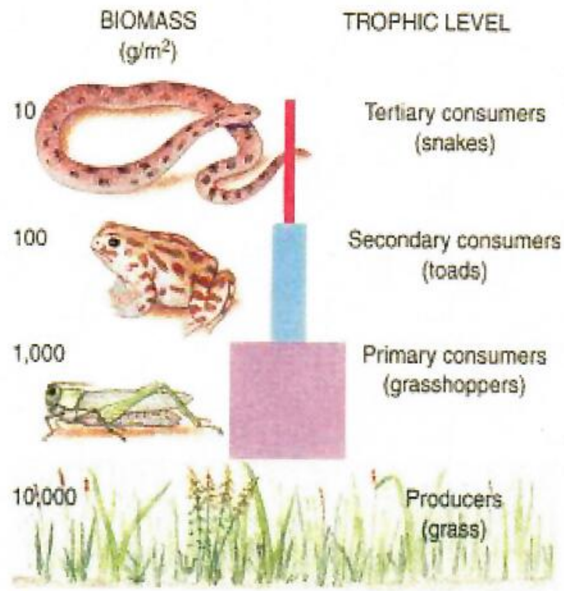
Grassland food web. *Image courtesy of*

Pyramids of Numbers & Biomass

A general pattern emerges from observing community structure based on trophic relationships.

- There are usually many more plants than herbivores
- There are greater numbers of herbivores than carnivores
- There are seldom more than a few top carnivores

This is the pyramid of numbers. Similarly, a pyramid of biomass almost always results if dry weight is substituted for numbers. The graphic illustrates both concepts for a temperate grassland.



Ecological Pyramid. There are more producers, by number and biomass, than herbivores. As you go "up" the food chain there are few and fewer numbers. ***Image courtesy of www.biologycorner.com.***

Top-Level Predators

The exceedingly small amount of energy available to the highest trophic level accounts for the fact that "big, fierce animals," those top carnivores, arc exceedingly rare. In fact, most top carnivores need to be highly mobile to cover the vast amount of ground needed to supply their energy needs. Home ranges of wolves and mountain lions, for example, are on the order of hundreds of square miles. Their predatory activities often form crucial energy links between neighboring ecosystems or landscapes. It also explains why many of these top carnivores are often on endangered species lists. Never existing in large numbers, encroaching development and increasing levels of habitat fragmentation are compromising their need for large expanses of suitable habitat. It is also putting them in more frequent contact with human activities, often with negative consequences.

The territorial needs of these predators are also posing a dilemma to conservation biologists. As wildlife habitat continues to shrink, biologists are recognizing that the long-term survival of many species may ultimately depend on our willingness and ability to set aside sufficiently large tracts of land as biological reserves. The important question is - How large of an area is needed to maintain a viable population of that region's largest carnivore? Is there the financial and political wherewithal to create at least one park or preserve on the magnitude of thousands of square miles? If not, we might not only lose those magnificent large predators but also the long-term stability of entire biological community of which they are important. perhaps critical members.

Biodiversity

Biodiversity = the number of different species found in a community.

One of the most striking global patterns is the marked increase in biological diversity, commonly referred to as biodiversity, as one proceeds towards the equator. Greenland, for example, is home to 56 species of breeding birds, New York has 105, Guatemala 469, while Colombia boasts 1,395! Tropical habitats are older, more productive, are structurally more complex (hence have a greater number of ecological niches), and have greater numbers of predators, thereby decreasing competition among prey species (recall the keystone predator effect).

Species diversity generally increases as we proceed through succession and species diversity leads to system stability.

In general, ecologists have observed that disturbed sites exhibit low species diversity, usually comprised of a few broadly adapted generalists, while undisturbed sites are comprised of a richer diversity of species, many of whom may specialize on a rather narrow group of resources.

Monocultures, communities dominated by a single plant species, such as those we frequently establish in growing our crops and landscaping our urban environment, are often unstable with regard to community structure, and often exhibit wide fluctuations in the population densities of the few species they support. Outbreaks of "pest" species and diseases are much more frequently encountered in these habitats than in more diverse communities. The "balance of nature" is more likely to be a reality within communities featuring complex food webs and numerous interspecific interactions. It is one reason we support homeowners replacing the typical "turf and trimmed trees" look with native landscaping, or wildscaping.