THE ECOLOGICAL SYSTEM

ECOLOGY

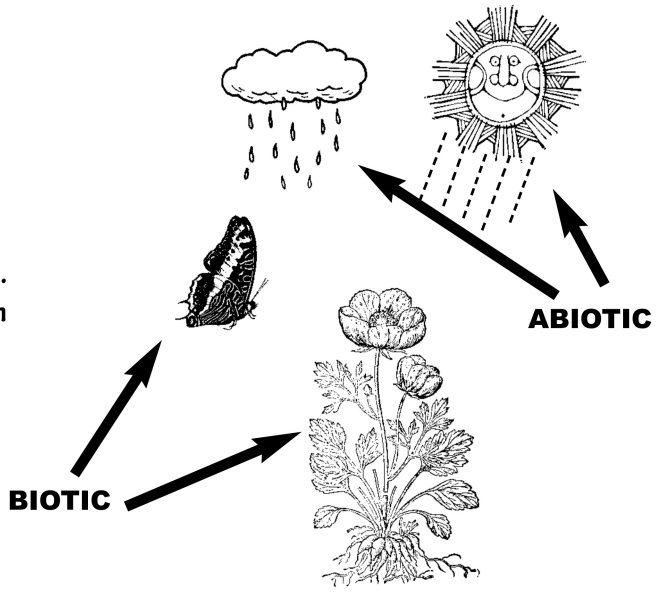
The word **ecology** is from the Greek root "oikos," meaning "house." Simply put, ecology is the study of houses or habitats, or more broadly, of organisms and their relationships to their environment. The modern scientist defines ecology as "the study of the structure and function of nature."

"I go to Nature to be
soothed and healed,
and to have
my senses put
in tune once more."

--John Burroughs
(1837-1921)
American Naturalist

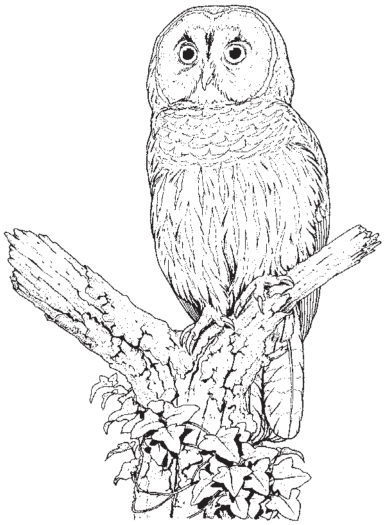
ECOSYSTEM

An ecological system, **ecosystem**, includes all the different organisms living in a certain area, along with their physical environment. While "eco" refers to environment, "system" refers to a collection of related parts that work as a whole. Some parts in an ecosystem are **abiotic**, or non-living, such as solar energy, water, rock, and minerals (chemical and physical components). Other parts are **biotic**, or living, such as plants and animals (biological). The ecosystem is the place where abiotic and biotic parts interact. Ecosystems are dynamic and complex. They change over time and space.

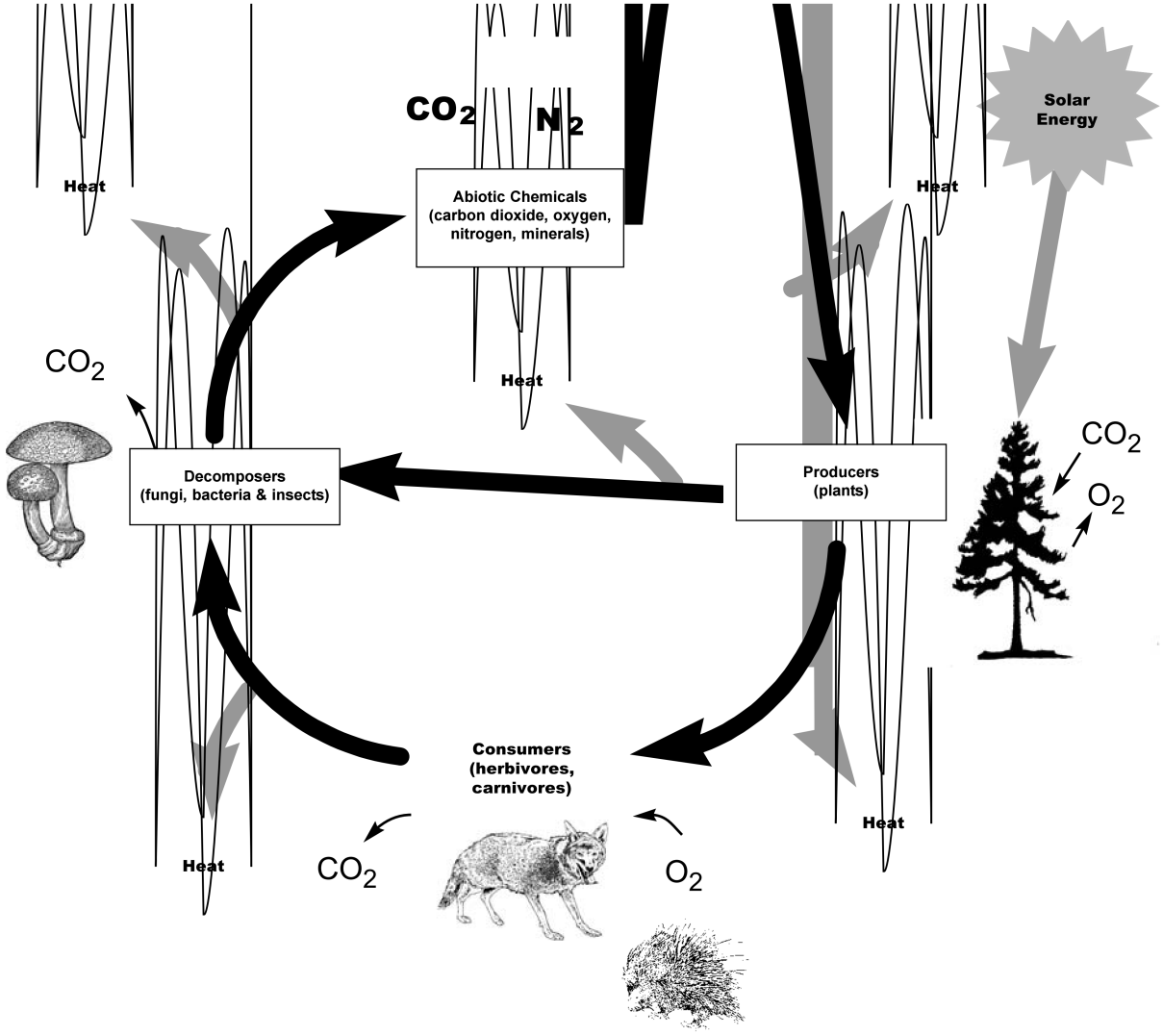


COMPONENTS OF AN ECOSYSTEM

The major components of an ecosystem are: solar energy; producers (plants); consumers (of plants, insects and animals); decomposers (bacteria and fungi); and nutrients important for growth (carbon dioxide, oxygen, nitrogen, minerals). For example, nutrients flow through plants and animals and return to the soil, air, and water (see *Food Web* to learn more).

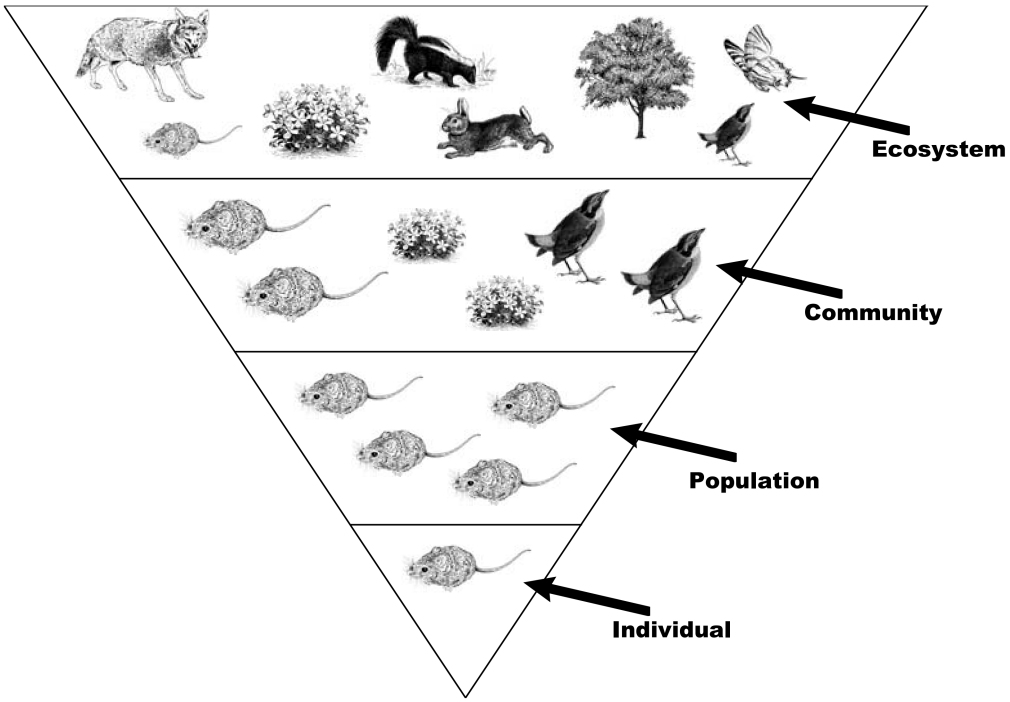


ECOSYSTEM STRUCTURE AND FUNCTION



SPECIES AND THEIR HABITATS

Biologists examine the biotic parts of an ecosystem as species, their habitats, populations, and communities. A **species** is the smallest unit of classification for biological organisms. Individuals of a species are alike in structure and function. **Individuals** of the same species can successfully breed with each other. Each species needs specific conditions to survive and reproduce. The place or location where an organism can meet these needs is called its **habitat**. Habitat can be described in terms of its structure. Habitat structure describes the shape, size and placement of abiotic and biotic features of an ecosystem. Because these non-living and living features change over time, so will the habitat structure.

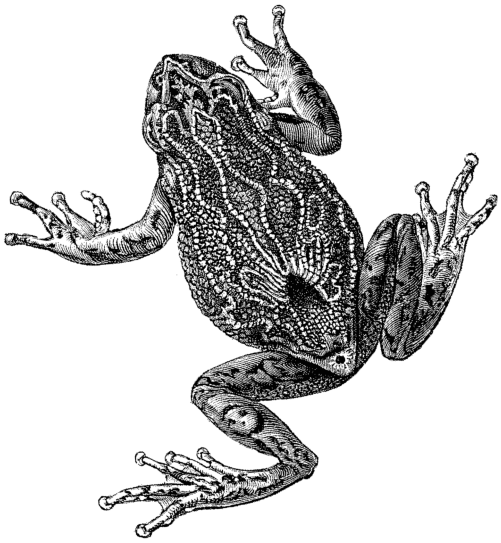


WHEN SPECIES COME TOGETHER

A group of individuals of the same species that live in a particular habitat are called a **population**. Different populations of species exist together in overlapping habitats in a **community**. Several different complex communities mix together creating an **ecosystem**.

FOR EXAMPLE:
Consider a Douglas-Fir tree (individual). The tree captures sunlight and uses water and soil nutrients to grow. The tree makes seeds in cones to reproduce, creating other Douglas-Fir trees (population). Other organisms that live on/in/off/with the Douglas-Fir that are tolerant of shade can grow and reproduce in the understory, below the Douglas-Fir tree (community). The Douglas-Fir trees, understory plants, and other organisms are part of the forest (ecosystem).

LOOSE BOUNDARIES



Because some organisms can move among ecosystems, it can be difficult to define the boundaries of an ecosystem. However, defining an ecosystem with loose boundaries may help us better understand how the natural world works.

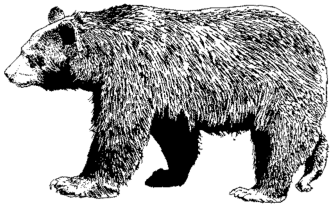
For example, frogs generally reproduce in a wetland ecosystem, but may also live in a forest ecosystem. The wetland ecosystem serves as breeding habitat and the forest ecosystem is important for rearing habitat.

NICHES

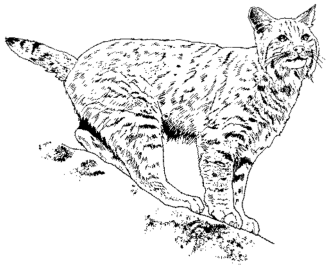
The way of life a species pursues within its habitat is called a **niche**. In other words, a niche is the role a species plays in its habitat. An organism's niche is composed of both biotic and abiotic parts. Some biotic factors that help define a niche are food sources and predators. Each species needs a specific types of food, such as insects or a species of plant. Temperature, the amount of sunlight and water are abiotic factors. All the biotic and abiotic factors taken together help define the organism's niche.

Within a niche, a species satisfies its basic needs in four specific categories (there may be others as well, like space):

FOOD, WATER , SHELTER AND REPRODUCTION



An organism's niche includes how much water it needs, what it eats, where it lives, what it uses for shelter from enemies and the elements, when and how it reproduces, how it raises its young and other such factors that make up its life. Some animals have very broad niches, like black bear. Black bear are **generalists** that eat a wide variety of plants and animals and can find food and water in a wide range of environments. Some niches are very narrow like the Lynx's. At times, this **specialist** will feed exclusively on snowshoe hares, thus limiting where it can live, reproduce and rear its young.



What do you think happens when two species try to share the same niche in the same habitat?

DISTURBANCE (CHANGE)

WHAT IS A DISTURBANCE?

An ecological **disturbance** is a change in an ecosystem caused by an event that disrupts or changes all or part of an ecosystem. This change can have many affects on both the abiotic, non-living, and biotic, living. Disturbances can be large scale, like volcanic eruptions, floods, or fire. They can also be less obvious and small scale, like a leaf falling into a stream, the gradual erosion of a hillside, a slight change in the temperature of a river, or the introduction of nutrients to soil or water. Over time, these minor changes may have a significant influence on the ecosystem.

ECOSYSTEM CHANGE

Events that cause disturbance alter the structure and function of ecosystems. They can change the species present in the ecosystem, the size and stability of populations, and the area where communities are located. Some organisms will thrive in a changed area, others will be displaced, or killed. When you study an ecological disturbance, consider:

TYPE

(of disturbance)

INTENSITY

(how severe the changes)

FREQUENCY

(how often it occurs)

The types, intensities and frequencies of past disturbance events provide key information about why an ecosystem looks the way it does today, and how it might develop in the future.

EVIDENCE OF DISTURBANCE

What disturbances could be indicated by the following pieces of evidence?

- ✔ charcoal in soil
- ✔ jagged edged stumps
- ✔ compacted soil
- ✔ fresh sand or silt deposits
- ✔ rounded rocks
- ✔ single plant species in the forest
- ✔ burn scars on trees
- ✔ numerous snags
- ✔ pole-sized trees bent over
- ✔ group of dead or dying trees
- ✔ debris in streamside vegetation
- ✔ ash and pumice mixed in soil
- ✔ even-aged trees
- ✔ tree tops missing

LOOKING FOR DISTURBANCE

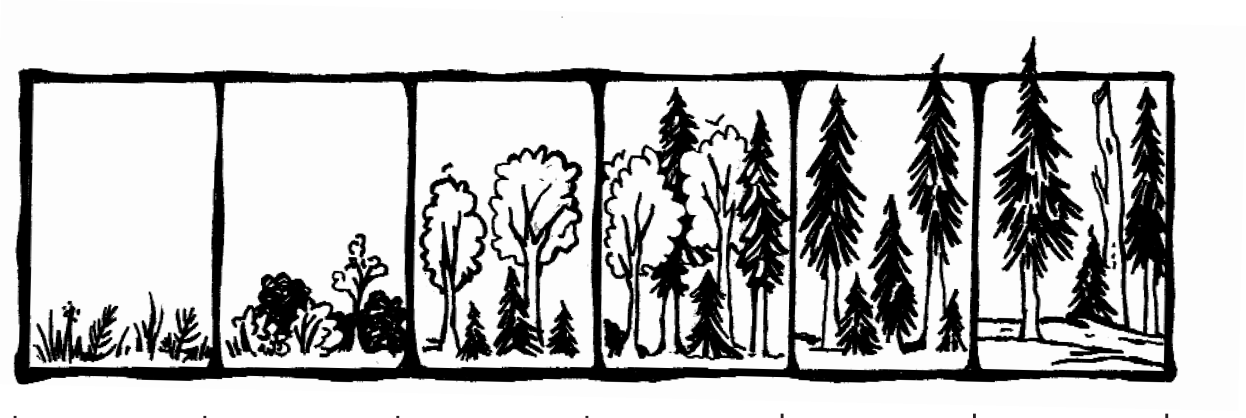
Consider how types of disturbances may have arranged, destroyed, removed or added different biotic components - such as the plants, soil, animals and insects - in the ecosystem that you are studying. Also, consider how the abiotic components have changed - such as the rocks, water, light, temperature - as a result of the disturbances. How would a large fire that burns all the trees in a forest be different from the harvesting of trees (clearcut)? How would organisms respond in an ecosystem that is regularly disturbed? How would the structure of a habitat change in the absence of a disturbance?

DISTURBANCE AND SUCCESSION

Change is a fact of life in all ecosystems, and living things respond to change in different ways. As an ecosystem changes, the community living in that ecosystem changes as well.

Consider the devastation on Oregon Coast Range forest ecosystems during the series of massive fires (1933, 1939, 1945 and 1951) called the Tillamook Burn. After the flames and smoke dissipated, leaving a charred landscape, organisms moved into this devastated habitat almost immediately. These communities sprouted from charred stumps or root crowns, or grew from seeds well-adapted to withstand intense heat. These first organisms were followed by others brought in by wind and wildlife. Fast-growing grasses and non-woody plants were followed by larger shrubs. Fast-growing trees, like Douglas-fir, then crowded out the shrub community. **Succession** is a pattern of changes in the types of species in a community over time. Many describe this as a series of steps towards a final destination while others consider succession to be a process or a cycle with no end or beginning. One description is linear while the other is circular.

CHANGES IN A FOREST COMMUNITY OVER TIME [1]



2-5 years	3-30 years	10-35 years	30-80 years	80-250 years	250 years
Grass Forb Meadow	Shrubs	Mixed Deciduous w/ Young Conifer	Mixed Conifer Topping Deciduous	Conifer Forest	Old Growth Forest

Immature Forest Community → **Maturing Forest Community**

[1] Note: this is a simple description (model) to help illustrate a complex process. In nature, there may be numerous variations of this theme.

DISTURBING QUESTIONS:

What natural event in May 1980 caused major disturbance in a large area of Washington state? How did that event change the biotic and abiotic components of ecosystems in the region? How could the event have changed ecosystems all over the world?

What major event in 1996 resulted in changes to many local stream ecosystems? How did that event change the biotic and abiotic parts of ecosystems in the region? How could the event have changed ecosystems all the way down to the ocean?

What natural and human disturbances have occurred in the last ten years in your area?

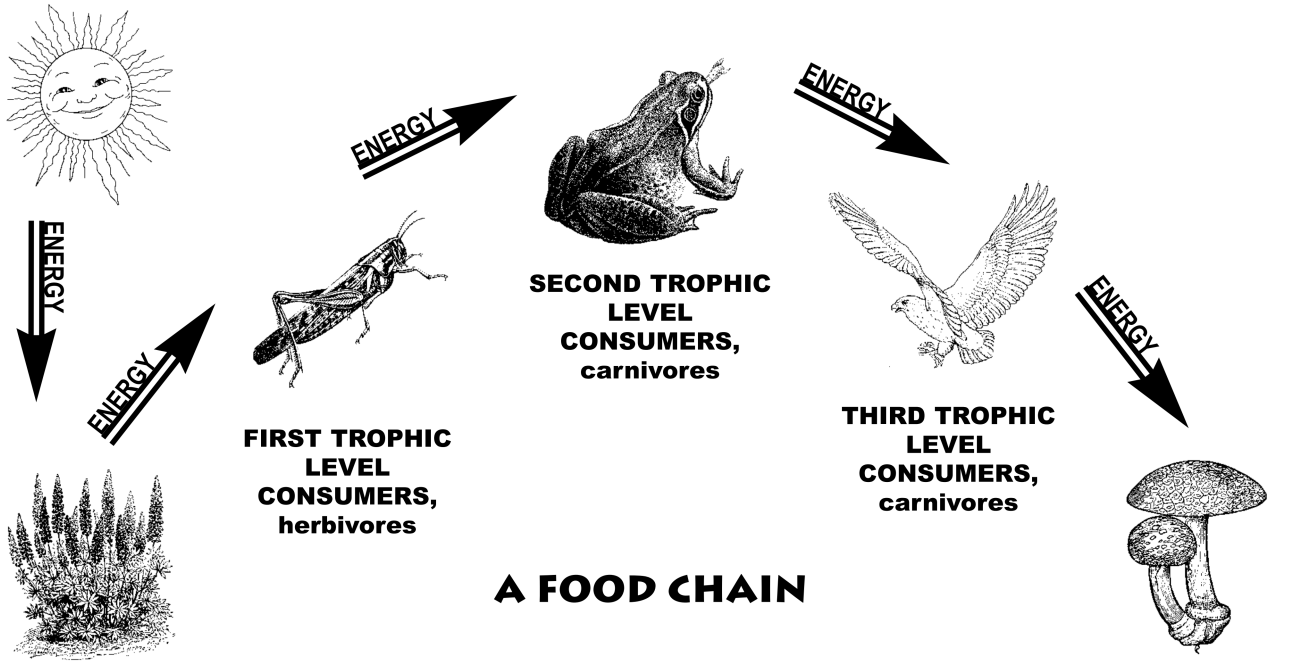
What disturbances might occur in a natural grassland on the plains of South Dakota? In a suburban backyard lawn?

FOOD WEB

THE TRANSFER OF ENERGY

A food chain is defined as the one-way transfer of energy from one organism to another in an ecosystem. Food chains are described using **trophic levels**. A trophic level is a category of organisms classified by what they eat.

A food chain begins with the transfer of energy from the sun, which is made into food by primary producers. Plants are usually the PRIMARY PRODUCERS that make up the first trophic level. The next trophic level is made up of FIRST LEVEL CONSUMERS, or plant-eaters, called **herbivores**. The next trophic level is made up of animals that feed on herbivores and are called **carnivores**. Animals in this trophic level are called SECOND LEVEL CONSUMERS. The next trophic level is made up of animals that eat other carnivores and are called THIRD LEVEL CONSUMERS. Organisms that receive energy from recycling nutrients by eating dead organisms are called **detritivores** or decomposers.



A FOOD CHAIN

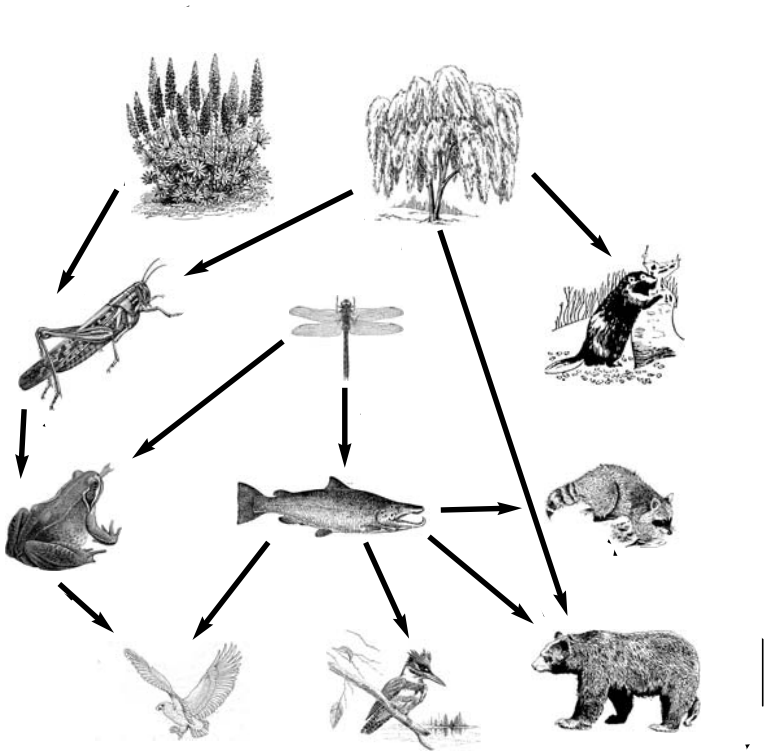
CHAINS CONNECT TO MAKE WEBS

Food chains are connected to other food chains, usually by upper level carnivores. The interlocking, complex pattern of food chains is defined as the food web. A **food web** is often used to describe the flow of energy and nutrients among all the organisms in an ecosystem. Changes in the population of one organism can affect many other populations within the food web.

"We do not weave the web of life;
We are merely a strand in it.
Whatever we do to the web,
we do to ourselves..."

--Chief Seattle (1788-1866)
Native American (Suquamish) leader

A SIMPLE FOOD WEB



"World Wide Web"

Suppose you ate an adult chinook salmon that you caught in a local river. Describe the possible organisms in your food chain (begin at the bottom with plants and end with yourself.)

Trace your food chain for the following:

a medium-rare New York steak

a bowl of Sugar Frosted Flakes

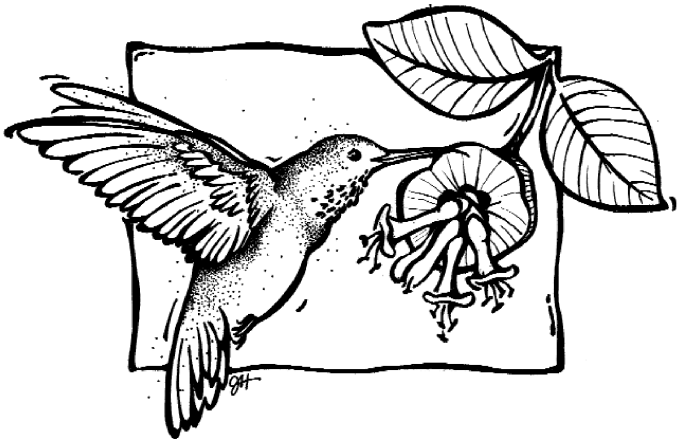
a steaming plate of sauteed Morel mushrooms.

A food web can have an infinite number of trophic levels. Some organisms can exist in many different trophic levels. For example, consumers that eat both plant and animal material, **omnivores** (like bears and raccoons) can be first and second level consumers. Animals that recycle nutrients by eating dead animal and/or plant materials (scavengers) also exist in many different trophic levels.

ADAPTATION

WHAT IS ADAPTATION?

An **adaptation** is a characteristic that may help organisms survive and reproduce in their environment. Adaptations can be genetic or learned.



Adaptations may occur to an organism's:

BEHAVIOR
BODY STRUCTURE
BODY PROCESSES
COLOR

For example, if an ecosystem has long, cold winters, a species may hibernate (a behavioral adaptation), have thick fur (a body structure adaptation), or have the ability to store a lot of fat (a body process adaptation). Animals that live in a snowy environment, like the snowshoe hare, become white in winter, to provide them **camouflage** from predators (a color adaptation).

The characteristics of plants and animals offer great insight to the physical and biological conditions of the ecosystem.

NATURAL SELECTION AND EVOLUTION

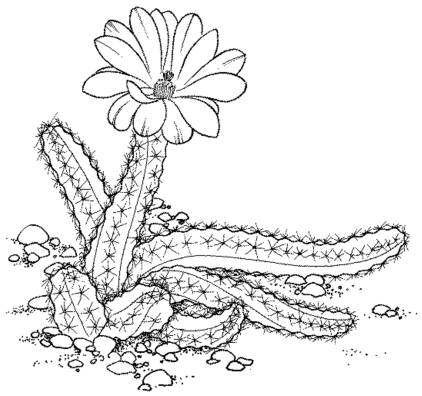
Charles Darwin, an English naturalist, proposed that the environment has a strong influence over which individuals have offspring. Some individuals, because of certain traits, are more likely to survive and have offspring than other individuals. He used the term **natural selection** to describe the unequal survival and reproduction that results from the presence or absence of particular traits. Darwin further proposed that over many generations, natural selection causes the characteristics of populations to change. A change in the genetic characteristics of populations from one generation to the next is known as ***evolution***. According to Darwin's theory, the process of natural selection is responsible for evolution.

EXAMPLES OF SPECIES ADAPTATION

PLANTS that experience drought (water or heat stress), like cacti, usually have some or all of the following characteristics:

Thick leathery evergreen leaves
Reduced leaf area
Deep root systems
Thick white hair or wax on their leaves.

These adaptations help reduce water loss, increase heat loss and/or reduce the amount of light absorbed by the leaf.



Some aquatic INSECTS, like mayflies, have adapted to live in fast-moving water. They have:

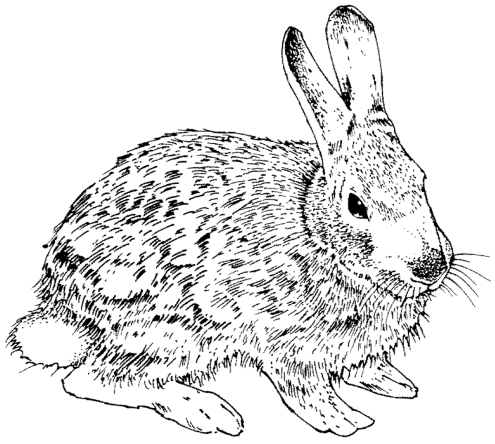
Flat bodies
Claws with hooks

These adaptations allow water to flow over the insects and help them cling to rocks in a swift current.

ANIMAL species that are often prey, like rabbits, evolved to have:

Large ears that can point in all directions
Eyes located on the outside of their head
A low body profile when on all four legs
The ability to stand upright on large rear legs

These adaptations give rabbits a keen sense of hearing, great peripheral vision, the ability to hide easily and stand upright to scope out potential danger.



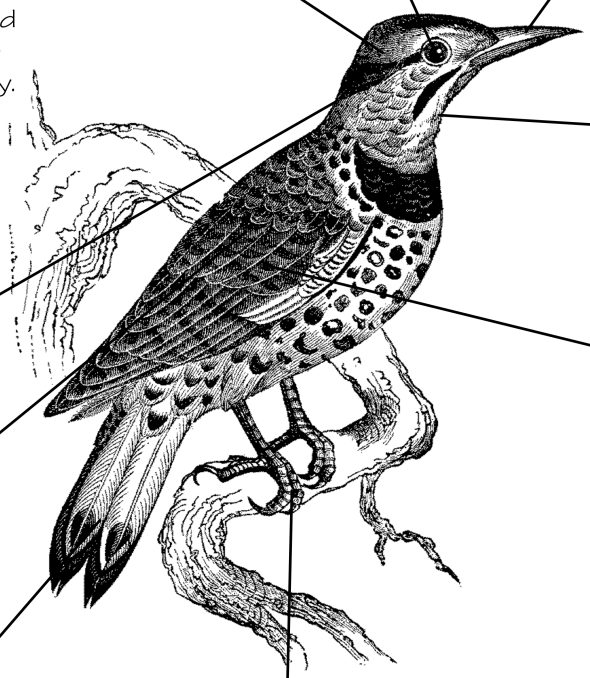
SPECIES ADAPTATIONS - NORTHERN FLICKER

Birds' sense of **vision is highly developed** to pursue food and avoid predators.

Birds have **good hearing**. They can distinguish notes that are far too fast for humans to separate.

Northern Flickers are a type of woodpecker. Woodpeckers use their **pointy beaks** to pick large insects out of tree and ground crevices. Their **long tongues** have spear-like tips that are used for stabbing their prey.

Flight takes an enormous amount of energy. Birds have a very **high metabolic rate** - the speed at which they can burn up food and turn it into energy.



Norther Flickers **call** a loud "kekekekeke" for territory advertisement. During courtship they **sing** "woikawoikawoika" in addition to drumming, wing and tail flashing, billing and bobbing.

Birds have more neck bones than most other vertebrate animals. A bird needs a **flexible neck** so that it can catch its food and also reach all parts of its body for preening (cleaning).

The secret of birds success in flying lies in the design of their **wings**, which **are light, strong, and flexible**. They are also slightly curved from front to back, producing an airfoil profile that pulls the bird upward as it flaps through the air.

Highly insulating plumage (feathers) keeps birds from losing too much heat.

A Northern Flicker's **long tail** is used for balance, perching, and for attracting the attention of a mate.

Birds have no teeth. The digestive system has to break down all the food. In birds that eat plant matter, **the gizzard grinds the food** into a pulp.

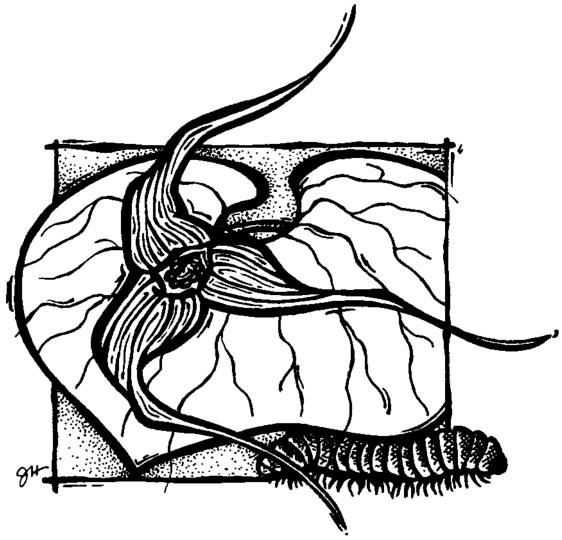
Birds have to stay within strict weight limits if they are to be able to fly. They do this with a **lightweight skeleton**. The long bones of flying birds are hollow and are reinforced with light weight internal supports.

Woodpeckers, like the Northern Flicker, have feet with two toes pointing forward, and two pointing backward. This **toe arrangement helps to anchor** them onto tree trunks and branches.

To survive in cold temperatures at a high altitude, birds have the **highest body temperatures** of all warm-blooded animals - up to 110^{o} F, compared with 98.6^{o}F in humans.

SPECIES RELATIONSHIPS

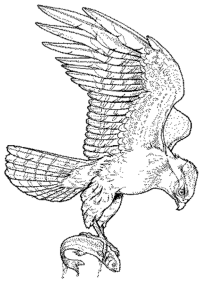
HOW SPECIES GET ALONG



Organisms of the same species and of different species are constantly interacting. The relationships between species have a large effect on the size of populations and how communities change over time. Species relationships can be investigated based on the effect the relationship has on each species. Some effects encourage the growth and reproduction of a species and other effects inhibit the growth and reproduction of a species. Some species relationships have little or no effect on one or both of the species.

EXAMPLES OF SPECIES RELATIONSHIPS

(Note: These are examples of relationships between individual organisms over a short period of time)



PREDATION

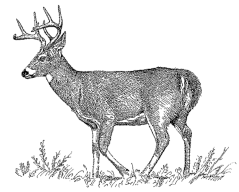
Along a river, an osprey flies down and takes a steelhead trout out of the water and eats it. In **predation**, one organism kills and eats another. The organism being eaten is called **prey** (the steelhead), and the one that does the eating is called the **predator** (the osprey).

COMPETITION

White bark pine trees produce large seeds within their cones. These seeds are collected and consumed by squirrels and grizzly bears. When the demand for the seeds is greater than the amount produced by the trees, these two organisms will compete for the same food resource. This is **competition**. Competition occurs when two or more organisms of the same or different species attempt to use the same limited resource. Anotherexample of of competition is the relationship between two plants competing for the limited amount of sunlight that reaches the forest floor or that are in competition for the same pollinators.

PARASITISM

The tick, a small arthropod, lives on the skin of some species of mammals such as mice, deer and chipmunks. The tick bites through the mammal's skin and eats the blood. The tick swells with the blood and falls off. The tick itself does not usually kill the host mammal. This is **parasitism**. The key difference in this relationship is that unlike predation, the parasite gets resources from its host without immediately killing it. The organism the parasite takes its nourishment from is known as the **host**.

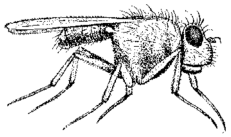


MUTUALISM

A honey bee is feeding on flower nectar. While the bee flies and eats from different flowers, it transfers pollen from one plant to another of the same species. While the bee pollinates the flowers, the flower provides a food source for the bee. Both species benefit. This is **mutualism**.

COMMENSALISM

A lichen attaches itself to the trunk or branch of a tree. The lichen enjoys a place to capture light, feed on nutrients from the air and receive moisture from water running down the tree. Although the tree provides resources for the lichen, the tree is unaffected. One species has benefitted and the other is neither harmed nor helped. This is **commensalism**.



NAME THAT RELATIONSHIP

Two trees are growing next to each other in the forest. They are the same height and their branches are growing into each other.

You are at a lake in the late afternoon. You notice fish rising to the surface to eat insects.

A mosquito begins to suck blood from your arm. You grab it and eat it. Is this parasitism, predation, cannibalism, all of these? (Hint: You are eating human blood).

HABITAT & SPECIES DIVERSITY

WHAT IS HABITAT DIVERSITY?

Habitat diversity refers to the variety of different places for organisms to live within an ecosystem. Habitat diversity is often determined by the types and arrangement of plant species, soil types, bodies of water and landforms (cliffs, rocky outcrops, etc.).

WHAT IS SPECIES DIVERSITY?

Species diversity is the variety of species in an ecosystem. There are two important components of species diversity: richness and evenness. Species **richness** refers to the number of species in an ecosystem. Species **evenness** is determined by comparing the numbers of individuals within each species. An ecosystem with a similar number of individuals of many species is considered to have high richness and high evenness. An ecosystem with only a few species, but equal numbers of individuals per species, is considered to have low richness and high evenness. Low evenness occurs when some species have many individuals, and some species have few.

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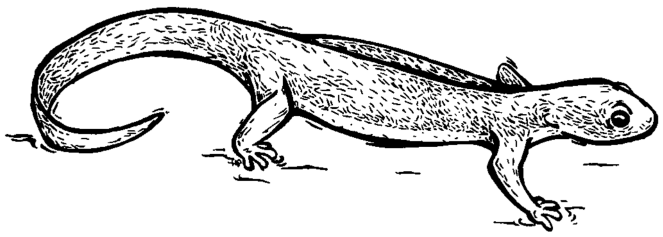


DIVERSE POPULATIONS?

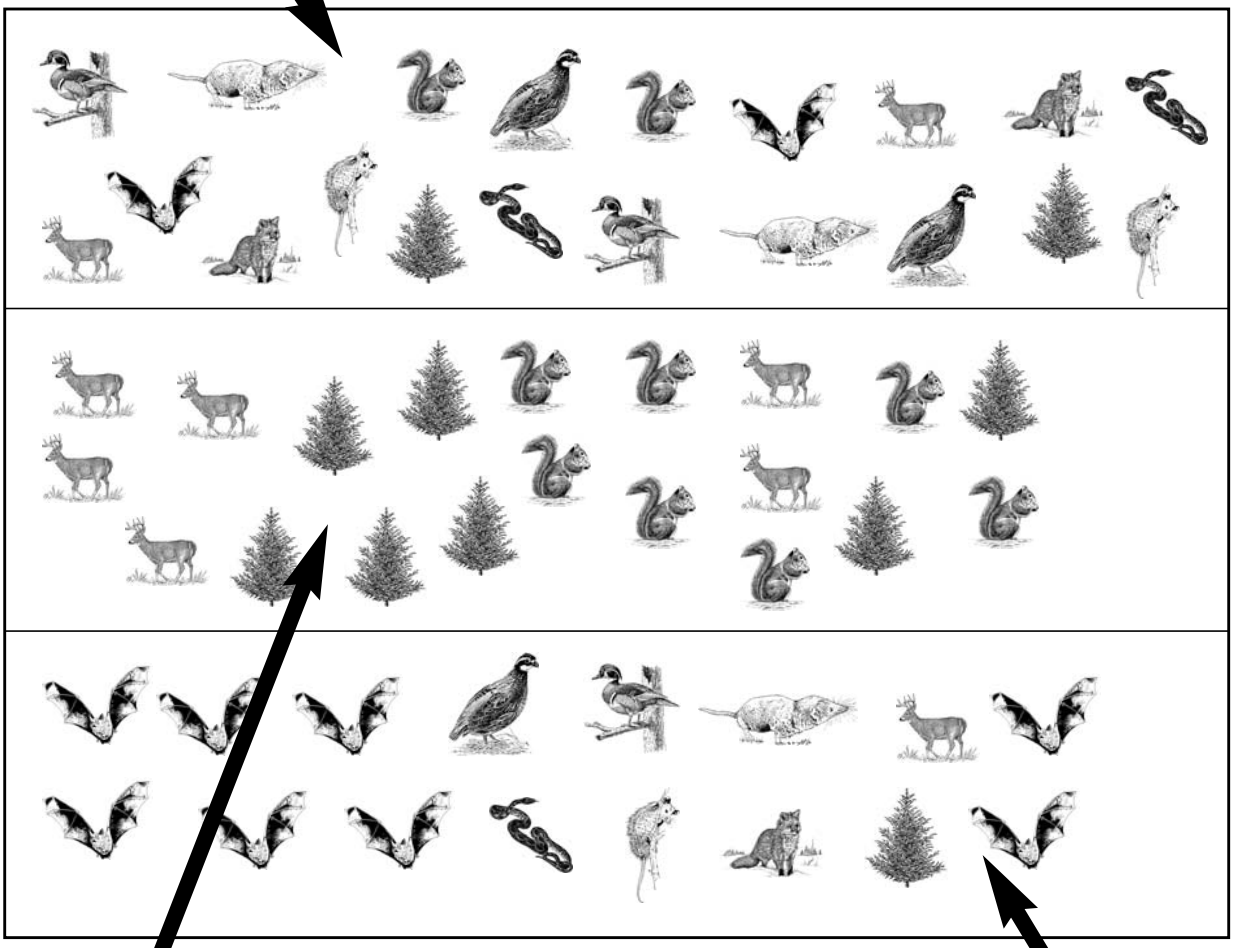
You are standing in your back-yard watching about 50 birds. You determine that there are four small black-speckled birds (starlings), one large blue bird (scrub jay) and 45 pigeons. Is this high or low species richness? Evenness? Why?

You are surveying plants in a wetland community. At the end of the survey, you have recorded:

10 species of aquatic grasses
3 species of algae
8 species of aquatic shrubs
5 species of wetland trees.

There are between two and five individuals of every species. Is this high or low species richness? Evenness? Why?

High Richness & High Evenness



Low Richness & High Evenness

High Richness & Low Evenness

HIGH AND LOW DIVERSITY

Different habitats provide food and shelter for many different species. Therefore, ecoystems with high habitat diversity often have high species diversity. An ecosystem with few habitat types may support a lower species diversity.

DIVERSITY AND ECOSYSTEM STABILITY

Species diversity helps determine the stability of an ecosystem. Each species differs in its ability to survive. Some species may be more well-suited to conditions after a disturbance or may even require a disturbance to exist. A diverse community is often able to recover more quickly from disturbance.