Ecology

It's barely morning and the top edge of the sun has just crested the horizon, its warming rays blanketing the meadow grasses. Earlier that morning the heavy, moist air had condensed on the sides of the grass blades. The larger dew drops ran together, dropping to the ground where they provided moisture for the worms, insects and bacteria that make the soil their home. Together with carbon dioxide from the air and light from the early morning sun, the same water will also be used by the grasses during photosynthesis to create food.

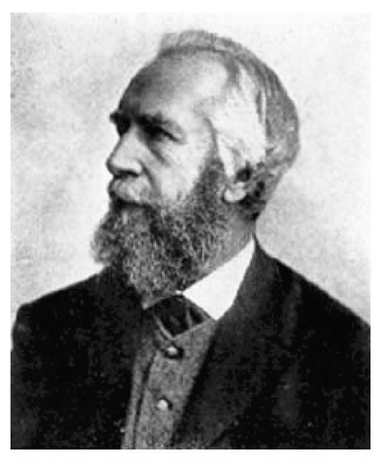
Even as the grasses gear up for their breakfast, a deer has been tearing mouthfuls from the meadow floor for nourishment, and the still-wet blades provide him with water, too. Although intent on eating, the deer does so warily, constantly on the lookout for unexpected sound, movement or odor. Suddenly he freezes, his gaze fixed on the far end of the meadow. There is no apparent movement in the meadow except the grasses swaying ever so slightly in response to a whisper of a breeze. Then he is gone.

Moments pass, then a mountain lion pads lazily from behind a coyote bush, entering at the far end of the meadow, exactly where the deer had been staring. She makes a circuit of the meadow, then departs for her den, leaving a trail through the tall grass marked only by the lack of dew drops that have now fallen to the ground. As the day progresses and the dew evaporates, this trail will become invisible to the eye.

These events could have happened at any meadow, at any point of time in the long evolution of grasses, deer, and mountain lion. It is a story of three characters whose lives are dependent upon each other. These relationships are the basis of the science of ecology. In this field, the black-tailed deer becomes more than just *Odocoileus hemionus*; it becomes part of a great soap-opera of interrelationships, each playing certain roles and allowing for life to continue.

The Study of Ecology

The term **ecology** is derived from the German "ökologie," a word coined by zoologist Ernst Haeckel to mean "the relationship of the animal to its organic as well as its inorganic environment." This German word, in turn, comes from the Greek "oikos," meaning "household," "home" or "place to live." The field of ecology has become the study of the natural environment and the roles that various organisms play in relation to their surroundings and to each other.



Ernst Haeckel

Within an individual's surroundings, there are physical characteristics and biological interactions that influence the organism. These factors are called its **environment.** Different species will have different relationships with their environment even though they may occur in the same location.

In his book, *Ecology,* Robert Ricklefs described the following example: "A squirrel and an oak tree inhabit the same place, bathed by the same sunlight, and drenched by the same rains; but the world of the oak includes the subterranean realm of its roots, which is completely foreign to the squirrel; the world of the squirrel is decisively affected by the bobcat, which merely passes the oak casually in pursuit of its prey." The predatory role that the bobcat plays in its environment seems to be completely separate from the oak tree, which produces its own food from sunlight energy– yet they are connected through the squirrel. The place where all these interactions occur is called the **habitat.**

The difference between a habitat and environment lies in whether we are looking at the big picture or at a more individualized picture. The habitat refers to the realm of the collective, where the flow of energy goes from species to species in a complex food web, usually distinguished by a dominant plant or physical characteristic. The forest habitat, where oaks, squirrels, and bobcats have all made a home, is an example.

The environment, however, refers to the world of the individual organism where physical and biological factors directly impact it. In the above example, the bobcat's environment includes a relationship with squirrels, but not a direct one with oaks, even though it may live in an oak forest habitat.

Niches, Adaptations, and Natural Selection

The organism and its role within a habitat, or its **niche**, is the fundamental unit in the study of ecology. How well an individual species fills its niche depends on how well it is adapted to its environment. Its **adaptation** refers to its physical and behavioral characteristics that enhances its ability to survive and could be based on exposure to several possible environmental pressures:

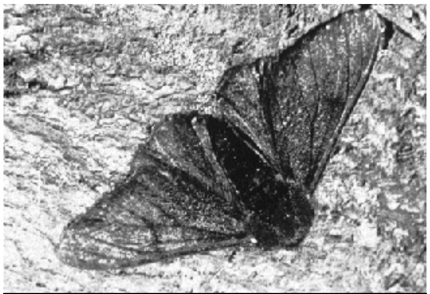
- ✓ physical and biological factors in the environment,
- ✓ predators, prey, parasites, and other similar interactions,
- ✓ social interactions with one's own kind.

As a result of these pressures, an organism will develop physical and behavioral adaptations that allow it to more effectively exploit existing niches, or create new ones. For example, fish use their gills to extract oxygen from their watery habitat, whereas coyote use lungs to capture oxygen from their world of gas. Beetles have hard exoskeletons, or shells, to protect their bodies, and banana slugs have a soft, slimy body that can ball up to prevent being swallowed.

The physical and behavioral adaptations that a species uses has evolved through a process called natural selection. **Natural selection** is the concept that individuals in a given population who are best adapted to their environment reproduce successfully, while individuals less fit for the environment reproduce less successfully, or not at all. This process allows a species to respond to its surroundings over time, changing as the environment changes. The idea is that future generations of the population constantly trend in the direction of increased fitness.

Rapid changes in the environment can increase the pressure on organisms to adapt. Alternatively, if a species exhibits **dimorphism,** the occurrence of two distinct forms, the environmental pressure can drastically change the relative frequency of the two forms.

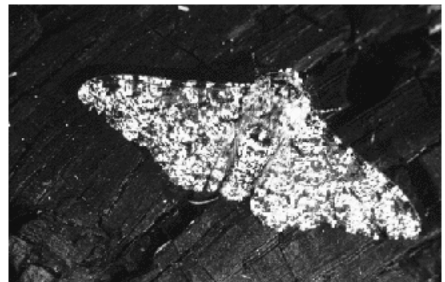
For example, during the previous century of industrialization, we were able to observe the effects of natural selection on a quickly changing habitat.



carbonaria variant

In the late 1800s, people throughout England began noticing that the common peppered moth, which was usually white in color, were appearing more often in its uncommon black mutation. Air pollutants in industrialized areas had tainted the bark of local trees black, causing the white individuals to be seen more easily by predators. Over a relatively short time, the surroundings in polluted areas had changed, causing the previously uncommon black moth to be more successful in camouflaging itself.

Interestingly, when increased social consciousness caused industrial cleanup and the reduction of air pollution, the tree bark lightened and the frequency of light-colored individuals in the pepper moth population increased once again.



Typica variant of *Biston*

Studies like these have shown that natural selection has an impact on a species' adaptations. Likewise, the physical adaptations help determine the niche, or job, that an individual fills in a given area. This niche has a direct bearing on an organism's place in food chains and food webs, or the hierarchy of who-eats-whom.

Who Eats Whom?

Picture in your mind the meadow, deer, and mountain lion which was described at the beginning of this section. The niches that they play can be categorized into one of three general levels: producers, consumers, and decomposers.

- ✓ **Producers** make their own food from chemicals and energy, such as sunlight. The most common are photosynthetic plants such as trees, shrubs, grasses, and flowers, as well as lower plants like algae, phytoplankton, and green protozoans.

- ✓ **Consumers** derive energy by eating something in their environment because they can't make their own food. Animals are consumers. Bacteria found in mammalian digestive tracts are consumers. And athlete's foot fungus is a consumer.

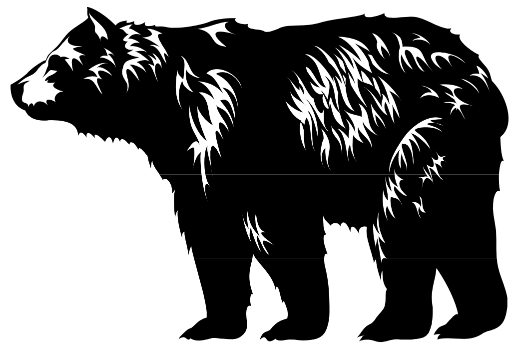
- ✓ **Decomposers** are very special consumers that extract nutrients from dead organisms. Their actions constitute the process of decay. Worms and certain insects are decomposers. When feeding on dead organisms, bacteria and fungi are decomposers.

When we look at the consumer level, we find that these organisms can be further divided into three categories: herbivores, carnivores, and omnivores. **Herbivores** are also known as primary consumers because they are the first in line to get their food, which comes from plants. They consume plants through the use of special enzymes, like cellulase, which allow them to eat plant leaves, stems, and bark, or by using special protozoans in their intestinal track which help to digest the difficult plant parts for them.

They acquire their food through several means:

- ✓ **Grazers** feed mostly on grasses, as sheep and cattle do.
- ✓ **Browsers** nibble on leaves, twigs, and other parts of trees and shrubs, as is common with deer and rabbit.
- ✓ Bears, bees, and certain birds are **foragers** who search for their food, be it fruit, pollen, or nectar.
- ✓ **Scavengers,** like millipedes or termites, consume decaying plant material.
- ✓ **Filter feeders,** like copepods, sponges, and tunicates, strain water for microscopic plants.

Predatory animals fit nicely into the **carnivore** category, also called secondary consumers because they are second in line to get their food. These are animals that feed on other animals. If they feed on herbivores, they are called a primary carnivore, and if they eat other carnivores, they are considered a top carnivore. Top carnivores are usually large animals, like wolves or mountain lion, that have no predators, and are only eaten by decomposers. All of the felines (cats) and most canids (dogs) are carnivorous. Parasitic insects are carnivorous. Weasels are carnivores.



Omnivores are equal-opportunity consumers, capable of feeding on either plant or animals. When food is scarce, it's good to be omnivorus. Opossums, raccoons, bears (except the polar bear) and humans are all omnivores.

Food Pyramids

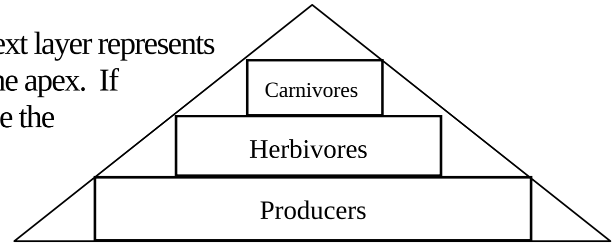
If you recall the meadow, deer, and mountain lion story once more, you would get an idea of a typical food chain. A **food chain** shows the flow of energy from sunlight to plant to herbivore to carnivore to decomposer. For example, the sun provides energy for grasses to grow in a meadow. As the grass grows, it provides food for deer, who, in turn, provide food for the mountain lion. The mountain lion will eventually die and its body will provide food for bacteria in the soil, which converts it into nutrients for plants, and the cycle begins again. The chain could be written as follows:

Sunlight ➜ meadow grasses ➜ deer ➜ mountain lion ➜ bacteria

When you connect several food chains together, you have a **food web**. For example we could start with grass which feeds grasshoppers, which, in turn, feeds lizards, which feeds a hawk, which provides food for bacteria. This same bacteria could provide nutrients for a coyote bush, which provides food for a rabbit, which is eaten by a coyote, which feeds a vulture, which are eaten by worms, which provide nutrients for grasses again. The food web shows us that ultimately all organisms depend on each other for food and survival, creating an interdependent network between them.

If we were to take a food chain and graph it, taking into account the total amount of energy that flows along it, we would have a **food pyramid**. We could graph the amount of energy; the total weight, or biomass; or the number of individuals. Whichever way we choose, we will end up with the same form: a pyramid.

The base of the pyramid contains the producers or the plants, the next layer represents the herbivores, followed by the carnivores, with top carnivores at the apex. If you examine the pyramid from the bottom to the top you will notice the following changes:



- ✓ The number of individual organisms decreases
- ✓ The size of the organisms often increases (herbivorous wildebeast, giraffe and zebras fed upon by lions or hyenas buck this trend)
- ✓ The total weight of living material, or the biomass, declines
- ✓ The amount of total and usable energy decreases, roughly 90% per level

Let's look at a sample food pyramid to demonstrate how this works. If we look at the following food chain: Grasses ➜ Deer ➜ Mountain Lion, and we count the number of individuals that are present in a habitat, we would find that there are many thousands of grasses, about 250 deer, and one mountain lion. This means that 250 deer are needed in order to support one mountain lion, and many thousands of grasses are necessary to provide for those 250 deer. It does *not* mean that one mountain lion will eat 250 deer, but that 250 deer are required to provide food and have enough left over to reproduce for the next season. Likewise, the 250 deer will not consume many thousands of grasses, but will eat some, leaving some for reproductive purposes.

Organism	Number	Biomass Weight
Mountain Lion	1	25 pounds
Deer	250	3,000 pounds
Grasses	Many thousands	Many tons

The same is true if we look at the total weight of living material, or biomass, at each level. If we weigh all the grasses available to our deer, we will find many tons of material. Not all of that biomass will feed deer, but some of it will be left behind to reproduce a new generation. The biomass of deer can be 2,500 to 3,500 pounds, some of which will go to support a 100-150 pound mountain lion.

Other Relationships

So far we have been discussing only short-term relationships in an environment, like predators versus prey, and how they determine who eats whom. There are also long-term relationships between two or more organisms, called **symbiosis**, which occurs when two or more species evolve together, forming an intimate and necessary association. There are three kinds of symbiotic relationship: parasitism, commensalism, and mutualism.

Most people are familiar with **parasites**, like tapeworms or ticks, which consume part of the tissue, fluid, or food of its host, usually without harming it. There are two types of parasites:

- ✓ **Endoparasites** live completely within the body of its host and include critters like virus, bacteria, protozoa, and worms.
- ✓ **Exoparasites** live on the surface of its host, and include examples like fleas and ticks on animals or mistletoe and bracken fungi on plants.

Parasites are organisms that receive room and board from their host at a minimum of discomfort. However, as anyone who has experienced a burgeoning pinworm population can tell you, the discomfort caused by parasites can become intense. Parasites can weaken and even kill their hosts; when the host dies, that is usually the end of the parasite, too.

Commensalism occurs when one organism benefits by the relationship and the other is minimally affected, or not at all. Think of a tree, its trunk and branches covered with moss or lichen. The moss and lichen benefit by receiving better environmental conditions like more light, while the tree receives no benefit (and, hopefully, no harm) at all.

The third type of symbiosis is called **Mutualism** and occurs in a relationship when both members benefit. For example, termites are able to digest the cellulose in wood because of a mutualistic relationship with a micro-organism that lives in their intestines. Like parasitism, there are two types of mutuaslism:

- ✓ **Facultative mutualism** is when the two organisms do not need to remain together, as in the example of bees pollinating flowers. Each can function as a free-living individual.

- ✓ **Obligatory mutualism** occurs when the two organisms are required to remain together to survive. For example, lichen is an organism consisting of fungus, which provides a structure, and algae, which produces food through photosynthesis.

Changes in Habitats

Have you ever climbed above tree line and noticed the rocks covered with a bright yellow, orange, or green growth? What you are seeing are the first stages of **succession**: the process of a habitat changing from one type to another. These mosses and lichen are uniquely adapted to grow in inhospitable areas, sinking roots into solid rock, acting like a sieve to hold particles in place and allow the beginnings of a soil to develop. Over time, as the soil thickens, grasses could move in, making the place their home. Eventually shrubs and then trees with their deeper root systems will take over, culminating in a **climax community**, or a habitat that has reached an end point in the successional sequence.

As an example, let's look at a meadow. Generation after generation of grass will live out their existence, eventually decomposing and helping to create a deeper soil over time. Animals who live in the meadow will also contribute to the soil development, eventually making it possible for different plants with a deeper root systems to live there. Shrubs may take over, squeezing out the grasses, creating a chaparral or other similar habitat.

As time marches on, young trees will creep in from the sides, eventually growing taller. The shadier conditions will once again limit the number of shrubs until a forest habitat remains. If this occurs in an area that has not previously contained a forest, then the process of one habitat being replaced by another is called **primary succession.**

Now let's add another change to the system like a fire or landslide, which removes the climax community and forces the process to start over. It now becomes **secondary succession**, in which the forest is removed and grasses could sprout up again. With time, the climax community will once again return until a natural or human-caused interruption starts the successional process over again.

Human Impacts

The natural world is one which is dynamic, yet stable. When an ancient tree topples in a wind storm, its body is broken down into nutrients for plants to grow in its place. The plants are eaten by others and life continues, cycling and recycling, ebbing and flowing, in an ongoing, never-ending process. Yet, as we walk through this dynamic forest of today, we know that it is also stable, having changed little over the past five, ten, or even a hundred years.

A problem occurs, however, when humans change the system. Modern large scale farming, historic logging practices, and predator extermination programs simplify the natural systems, causing instability with sometimes devastating results. Row upon row of single species of food crop or timber may require tremendous energy to protect from choking weeds, hungry insects, and fungal pests. The eruption of resistant strand of pests can destroy entire industries.

An incomplete understanding of the complex relationships within our environment can lead to surprising results. Sheep farmers still commonly believe that coyotes are a threat to their livestock. Therefore, extermination of these canids seems to be a sensible goal.

However, in his book *A Natural History of California,* Allan Schoenherr explains: "A controversial war on the coyote (*Canis latrans*) continues, in spite of evidence showing that coyotes eat mostly vegetable material, not livestock. They eat an abundance of meat only when small mammals such as mice and rabbits become too numerous. When rabbits become too common, they eat crops. Coyotes thus serve as a natural control mechanism."

Over the years we have discovered that we, too, hold a place in this great soap-opera of interrelationships. We have evolved adaptations which allow us to hold a powerful niche in the system, one that gives us the ability to significantly effect the whole. In the past, we were unaware of our place, thinking that perhaps we were somehow removed from it. But every move we made had its impact. Today, we are learning that to take an action anywhere in the vast web of life, will have is repercussions – like throwing a rock in a pond and watching the water ripple out in waves from the point of impact. We are learning that perhaps our role in the world is not that of exploiter, but as caretaker.

Conclusion

This Ecology section has been all about the relationships of the living world. Producers, consumers, and decomposers all link into a united system where energy flows from one level to another, producing a vibrant whole, humming with life. The meadow habitat described at the beginning of this section is filled with grasses which produce their own food and eventually die, preparing the soil for the next stage of succession.

The deer that feeds on the dew covered grass, fills an herbivorous niche and is highly adapted to detect possible danger, fleeing at its first signs, but eventually becoming food for another. The mountain lion is a solitary, nocturnal predator adept at stalking its prey, only becoming seen when its too late. Linking them together are the bacteria, worms, and insects that decompose their lifeless bodies into life-giving nutrients, so that the cycle can continue.

We humans are finally beginning to see that we are not separate, but part of this system – adapted with the ability to think and analyze, and thus understand our place within it. It is as Alexander Von Humboldt said: "the wealth of the natural sciences no longer consists in the abundance of facts, but in the way they are linked together."

Understanding our interdependent world promotes an appreciation for it, while at the same time giving us a responsibility to protect it – just as we've done with Quail Hollow Ranch. This ranch has been protected in the form of a park, giving us the chance to observe first hand the delicate, intricate interrelationships that are present in nature.

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