FOREST Ecosytems – Community Connections

Section 2
FOREST INSIGHTS

The forest ecosystem is like a finely woven tapestry. Elements of the **nonliving environment** – climate, soil, topography (*see* INSIGHTS, *Section* 1) – create the support threads, while a myriad of living things supply the pattern threads. The energy exchange and interactions between and among nonliving and living things weave the threads into the forest tapestry we see around us.

Energy Transfer – *the basis of all life*

Where the next meal comes from is a constant priority in any organism's life. The following pages describe how energy is transferred and materials are recycled in forest ecosystems. Recycling here is not just an option, but is critical to continued survival of the ecosystem.

FOOD WEBS – WHO EATS WHOM?

[*see the following "Forest Facts" for the Five Kingdoms of Life, and* Alaska Ecology Cards *for more species illustrations*]

Producers. A plant is exquisitely equipped to convert the nonliving — air, water, minerals, and sunlight — into food for itself and others. Plants and algae that make food from nonliving materials are called **producers**.

Consumers. The other living things in the forest that depend on food manufactured by producers are called **consumers**. Consumers divide into four groups: **herbivores** (animals that eat plants), **carnivores** (animals that eat other animals), **omnivores** (animals that eat both other animals and plants), and **detritivores** (animals and other organisms that eat dead or decaying material).

Food Chains and Web. The pathway of **energy** and **minerals** from the nonliving environment, through producers, to consumers, and back again through detritivores creates a **food chain**. All the food chains of a forest are connected into a **food web – the energy circulatory system of an ecosystem**.

Energy Lost and Found. At each intersection in the web, some energy is returned to the nonliving environment as heat. That energy is not passed on and cannot be reused by living things. The lost energy is replaced during photosynthesis by the capture of energy from the sun.

Mineral Recycling. Minerals are always passed along at each web intersection until the detritivores return them to the environment in a form usable by plants. The producers use them again to make new food – and the cycle continues.

PRODUCERS CONVERT RAW MATERIALS

Using the process of **photosynthesis**, producers combine energy from sunlight with carbon dioxide from the air and minerals from water, soil, and rocks to produce the sugars and oxygen that help all other living things survive. Plants, algae, and lichens are important producers in forest ecosystems and are the first life forms in food chains.

Measuring Production. Scientists measure this flow of energy and minerals by determining the weight of carbon that is "fixed" or changed into living material by producers each year. Basically, the measurement is the dry weight of all new growth – leaves, roots, flowers, seeds – produced each year.

High Productivity Compared to Tundra. On average, forest producers together make 3 to 10 times as much food each year as producers in tundra ecosystems. That is why some tundra consumers migrate to forested environments for part of the year (*see* Alaska's Tundra & Wildlife, *Section* 3: "*Migration*").

HERBIVORES EAT PRODUCERS

Some of the largest and smallest forest wildlife are herbivores. Moose, deer, and snowshoe hares receive all their nutrition from the stems, bark, and leaves of plants. Porcupines grow strong on the cambium layer of trees. Dozens of other small animals prefer tree seeds (red squirrels, mice, voles, juncos, grosbeaks, and crossbills).

Multitude of Busy Invertebrates. Yet, these examples are overwhelmed in number by the smallest forest herbivores – the millions of leaf-eating, wood-drilling, sap-sucking, twig-boring insects and other often overlooked invertebrates.

To Each Its Own Meal. Each herbivore is adapted to eat specific kinds of plants and cannot live where those plants are absent.

Some Plants Defend Themselves. In defense, some plants create barriers against being eaten. Devil's club arms itself with prickly spines. Alder and spruce trees produce chemicals that make their leaves toxic or taste terrible to many herbivores.

Starvation in Midst of Abundance? Sometimes even if a favorite food plant seems abundant, animals can be thwarted by a plant's defenses. Birch and willow saplings, for example, are favored by snowshoe hares. But after the hares start to devour them, those plants produce so many chemicals that the hares stop eating them. Many have died of starvation.

Plants Linked to Hare/Lynx Populations. Some scientists think that birch and willow plants may cause the 10- to 12-year cycle of highs and lows in the numbers of snowshoe hares and, in turn, of their main predator, lynx. (*Student Activity "Predator/Prey Predicament" in* Alaska's Wildlife Conservation *lets students actively examine this situation*.)

CARNIVORES EAT HERBIVORES — AND EACH OTHER

Herbivores such as voles, snowshoe hares, marmots, moose, and deer are food for many carnivores (lynx, foxes, owls, hawks, weasels, wolves, and bear). Another name for carnivore is **predator**, one that kills and eats other living things.

Some Insects Prey on Insects. Herbivorous insects are food for insect-eating carnivores (shrews, woodpeckers, warblers, thrushes, beetles, spiders, centipedes, and carnivorous plants such as sundews).

Carnivores Do Not Discriminate. Carnivores do not limit themselves to dining on herbivores. All will eat each other if the opportunity arises.

Amount of Herbivores Influences Carnivores. Carnivores cannot survive without adequate populations of prey. So the numbers and kinds of herbivores in a forest, in part, determine the presence and abundance of carnivores.

Carnivores Impact Numbers of Herbivores. Carnivores influence the numbers and kinds of herbivores in a forest, too. If a population of herbivores grows too large, those animals may eat all their food supply and starve. Healthy populations of carnivores (predators) reduce the chance of such herbivore population explosions and crashes. When an explosion does occur, carnivores lessen the effects on plants.

Predators to the Rescue. Scientists studying the spruce budworm in the Pacific coastal forest discovered that ants and birds prey on so many budworms that they decrease the amount of tree damage by one-half.

Tiny invertebrate animals in the soil (*detritivores*) eat nine times more forest plant material than all the moose, deer, voles, birds, and other large-animal plant eaters (*herbivores*) combined.

OPPORTUNISTIC OMNIVORES

Food in the forest can be scarce, especially for big eaters. Therefore, consumers that eat a variety of foods have a better chance of survival.

Bears Say Yes to Everything. Bears are good examples. They eat roots, grasses, herbs, and berries as well as small and large mammals, insects, fish, and carrion. With an omnivorous diet, bears are well-adapted to whatever the season offers.

Mosquitoes Need Blood, Nectar. Mosquitoes are infamous for their abundance in Alaska. Both male and female mosquitoes sip plant nectar as herbivores, but the female is omnivorous. She needs a blood meal from a warm-blooded animal to produce the eggs she will lay on the surface of any nearby water.

DETRITIVORES REUSE AND RECYCLE

The greatest number and variety of consumers in any ecosystem are the detritivores which eat dead things and waste materials.

Essential for Ecosystem Operation. They are very important to the forest because they return all the minerals stored in the food chains to the soil for reuse by forest plants. Without detritivores, producers would soon run out of the minerals they need to make food, and the forest would smother in tons of debris.

Big and Small. Some well-known animals such as ravens, crows, and bald eagles are detritivores. But the most important detritivores are tiny, extremely numerous – and ignored. These include animals that live in forest soil, many **fungi**, and a multitude of **microscopic organisms**.

What's Under Your Foot? Every time you put your foot down in a forest, you are stepping on tens of thousands of (1) tiny animals, (2) miles of fungi, and (3) an almost unimaginable number of microscopic organisms.

Too Much to Consume. Every year about one to two tons of plant debris fall on each acre of forest floor. It takes all the kinds of detritivores to keep up with the task of digesting that organic material.

(1) *Animal detritivores eat more plants than moose!*

The most noticeable detritivores are tiny animals without backbones (**invertebrates**) – **mites**, **springtails**, and **nematode worms**, all dormant through the winter in the boreal forest.

Thousands Under Foot. Mites, tiny bright-red relative of spiders, can be as thick as 10,000 under a footstep by late summer. Springtails, an mobile insect without wings, might number 2,000 per footstep.

Can You Hear Them Chewing? Scientists in Fairbanks calculated that these tiny animals would form a mass of 34,000 pounds in one square mile of boreal forest soil. They say that would be equal to 43 moose in body weight.

Olympic Consumers. Therefore it is not surprising that these small animals eat most of the food produced by forest plants. According to some estimates, these tiny invertebrates in the soil eat nine times more plant material than all the moose, deer, voles, birds, and other large-animal herbivores combined.

(2) *Fungi detritivores – an out of body experience!*

Fungi are by far the most prolific of all the detritivores in our forests because they are adapted to acidic soils. Mushrooms, shelf fungi, and less noticeable molds, mildews, and rots are some examples.

Fungi Rate Own Kingdom. Fungi are similar to plants in that they are immobile. In fact, scientists used to consider them to be plants. But fungi are very different from plants in cell structure and in the ways they live, so scientists now place them in a separate kingdom of living things.

More Than Meets the Eye. Usually, we see only the fruiting, or reproductive part of a fungi (*a mushroom, for example*). Its main body is hidden from view. The body of a fungus is made up of **hyphae**, microscopic hair-like structures that reach out through forest soil or into trees. A handful of forest soil may contain over two miles of fungal hyphae!

Unusual Way of Eating. Fungi use their hyphae and digest their food outside their bodies! The cells of fungal hyphae give off digestive enzymes like those found in our own stomachs. These enzymes break down wood, leaves, and other material. Then the fungal hyphae absorb the scattered sugars and minerals and use them to grow.

(*For more information about the Five Kingdoms of Life including Fungi, Protista, and Monera, see Forest Facts in this section.*)

(3) *Microscopic detritivores – small but mighty*

Like fungi, **monerans** and **protists** play a large role in creating soil. Until recently, these microscopic living things were considered to be small versions of plants and animals. But scientists recently created two new kingdoms for them.

Million on the Head of a Pin. Monerans, the smallest microscopic organisms, do not have nuclei in their cells. **Bacteria** and **cyanobacteria** (or **blue-green algae**) are examples of monerans. A *million monerans would fit on the head of pin*.

Protists Live, Eat in Group. Larger microscopic organisms that have cell nuclei are called protists. These include **algae**, **paramecia**, **amoebas**, and many others. Some protists live together in large groups that can be seen without a microscope, but the individual organisms are microscopic.

Microscopic Recycling Factories. Although some of these microscopic creatures are herbivores and others are carnivores, the majority (especially monerans) are detritivores. They are primarily responsible for returning minerals in waste and dead things to the soil for re-use by plants and other producers, ensuring that the cycle of life can continue.

Community Interactions – competition & symbiosis

The forest food web just described portrays life and death relationships in the forest ecosystem. There are other equally influential relationships that do not involve eating the next in line: **Competitive relationships** occur within and between species. **Symbiotic relationships** (literally "*living together*") describes three forms of forest neighborliness: **mutualism**, **commensalism**, and **parasitism**.

COMPETITION – I can grow faster

Competition occurs when the supplies of energy, minerals, and space are limited. Any plant or animal that can get more water, more minerals, or more energy, more space, or better shelter than its neighbors will grow better and leave more offspring.

All Fair in Competition. Plants have a variety of adaptations to help them compete for the resources they need for survival and growth. Some plants grow tall, like trees, to get more of the available sunlight energy. Plants with long roots reach farther and get more water and minerals than those with short roots. Some plants produce chemicals to kill the roots of other plants and assure a larger supply of minerals and water for themselves.

More than 90% of Alaska's plants could not grow without a certain fungi that helps them absorb minerals.

Your Food? My Food! All living things compete with similar organisms to one degree or another. Herbivores such as moose and snowshoe hares eat the same kinds of plants and compete with one another for available food. Carnivores such as weasels and foxes eat the same kinds of prey and compete.

Constant Interaction in Ecosystem. Birds such as chickadees and swallows need the same kinds of nest sites and compete with one another for the available sites. Competition is a constant interaction. The specific mixture of organisms in any forest is due in part to the effects of competition.

MUTUALISM – the friendly symbiosis

Both organisms benefit from the symbiosis of mutualism. The relationship of flowering plants to the animals that carry their pollen is a good example.

A Nutritious Attraction. Flies are attracted to decaying things, so some flowers (chocolate lily) actually produce rotten odors to attract flies. Both plant and pollinator benefit. The plant gets its pollen carried to other flowers, and the insect receives nectar, or food, from the plant.

Aerating the Soil. Many insects and small herbivores such as voles help forest plants by tunneling through forest soil in search of food. Tunneling creates spaces for air and water to seep, mixes the soil, and helps speed decay of organic matter and recycling of minerals.

Larger Benefits for the Species. Even though herbivores harm some individual plants by eating them, many of those plant species would not grow, expand their range, or survive without herbivores.

Beg to be Eaten. Some plants benefit by producing tasty seed pods. When an animal eats that food, it digests only the fleshy part, and the hard-coated seed inside passes through the animal's digestive tract intact. The seed thus gets a ride to a new area where it may grow.

Secondary Processing of Seeds. Some plants, like dwarf dogwood, produce seeds that will not grow unless they pass through the digestive tract of an animal first! Red squirrels also spread spruce seeds this way as well as when they forget where they buried their cones.

Fungi aid plants in mineral absorption

One of the most important mutualistic symbioses in a forest is the association between plants and certain fungi called **mycorrhizae**. The hyphae of these fungi seek out the roots of plants, and then grow around or even into the plant's fine root hairs.

Mutual Help. At one time scientists thought these fungi were harming the plants. Instead, they actually help plants get minerals from the soil.

Minerals Not Otherwise Available. In one study scientists found that a pine tree living with mycorrhizal fungi grew twice as fast and absorbed 86% more nitrogen, 75% more potassium, and 234% phosphorus than did a tree without mycorrhizae. In addition, scientists now think that some mycorrhizal fungi actually help protect plants from certain diseases.

In Trade for Sugars. The fungi also benefit from the association. Plants pump sugar made in their leaves down to root hairs. This provides energy for the fungi. Many of the mushrooms we see in the forest are the fruiting bodies of mycorrhizal fungi.

Owe Our Trees and Berries to Fungi. More than 90% of the plants in Alaska, including all our trees and berry-producing plants, could not grow without these mycorrhizal fungi.

Moneran bacteria help release nitrogen

Another important mutualistic association occurs between certain plants and monerans. Plants must have nitrogen in order to grow, but they are only able to use nitrogen that is in the soil. Most of the nitrogen on earth is in the air, making it useless to plants.

Nitrogen – Fixers Aid Plants. Microscopic bacteria known as "nitrogen-fixers" take nitrogen from the air and convert it to a form that is usable to plants.

Why Alder is a Pioneer Plant. One example in Alaska occurs between alders and nitrogen-fixing bacteria that live in bulbous growths on alder roots. The bacteria takes the nitrogen from the air and converts it to a form that is usable by alders. In exchange the alder provides sugars (food) that the bacteria need. This symbiosis allows the alder to grow on poor soil where most other plants cannot survive. The alder/bacteria combination improves soil conditions for future plant growth.

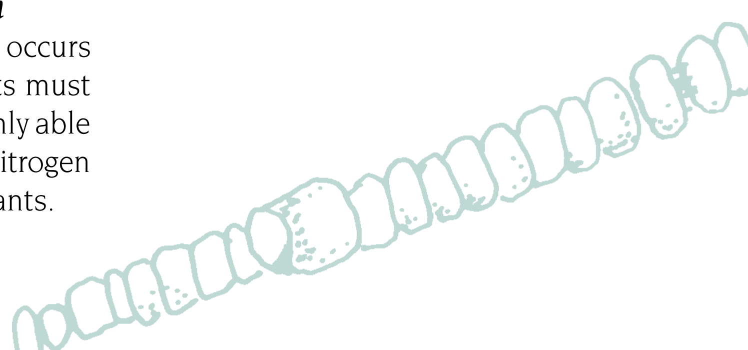
COMMENSALISM – no harm done

In commensalism, another form of symbiosis, one species benefits while the other is neither helped nor harmed.

A Nest Cavity for Free. Woodpeckers dig holes in trees for nesting and winter roosting, but they use them only for a year or two. Owls, which cannot dig holes in trees, are able to use the abandoned woodpecker holes as nest sites.

No Harm Done. In this symbiosis, the owl benefits from the woodpecker's efforts, but the woodpecker, which had abandoned the hole, is not affected.

Transplanting Seeds. Moose and other large forest animals give free rides to grass seeds that get caught in their hair.



PARASITISM – a win/lose situation

In the third type of symbiotic relationships, the parasite benefits and the host is harmed or eventually killed. Parasites fulfill useful roles in the forest ecosystem by helping to prevent plant and animal population explosions.

Tree Case Study. A fungi (*the parasite*) lands on a tree (*the host*) and infiltrates the bark. The hyphae of the fungi spread up and down from their entry point. As they grow, the hyphae break down and digest the tree trunk. The tree fights back by walling off the sections invaded by the parasite. The tree resists the fungal invasion and survives for many years, but eventually some fungi kill the tree.

Eventually Someone Benefits. Although parasites harm, they are part of the natural cycle of life and death. A tree killed by parasites becomes a shelter for organisms that live in dead trees. Detritivores now have a new source of food and minerals for recycling. And by dying and falling, the tree opens the canopy, letting in more sunlight and providing space for new trees and plants to grow.

Tapestry Pattern

Living things are bound together and to their nonliving surroundings in many ways – like patterns in a tapestry. Cut a few threads in a weaving: the piece still holds together. Cut too many: the tapestry weakens until it unravels.

Similarly, a forest ecosystem can survive some changes. Each small change, however, affects many members of the forest community through the interrelationships of food webs, symbioses, and competition.