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, author of A Sand County Almanac

CHAPTER TWO FOREST ECOSYSTEMS

While trees sometimes stand alone, most often they are part of a community called a forest. Forests consist not only of living ***(biotic)*** components like trees, animals, plants, and other living things but also of nonliving ***(abiotic)*** components such as soil, water, air, and landforms. All of these components together make up a forest ***ecosystem.***

Systems

Forests are more than collections of living and nonliving things found in the same place. Their many components are connected to each other as food chains of interdependence. Food chains move the basic requirements for life—energy, water, carbon, air, and nutrients—in a series of connections and processes.

All food chains consist of:

Producers—organisms that produce energy

Consumers—organisms that consume producers and other consumers

Decomposers—organisms that consume producers and consumers, and provide nutrients into the soil.

Applying the ***system*** above to a simple real-world example is as follows:

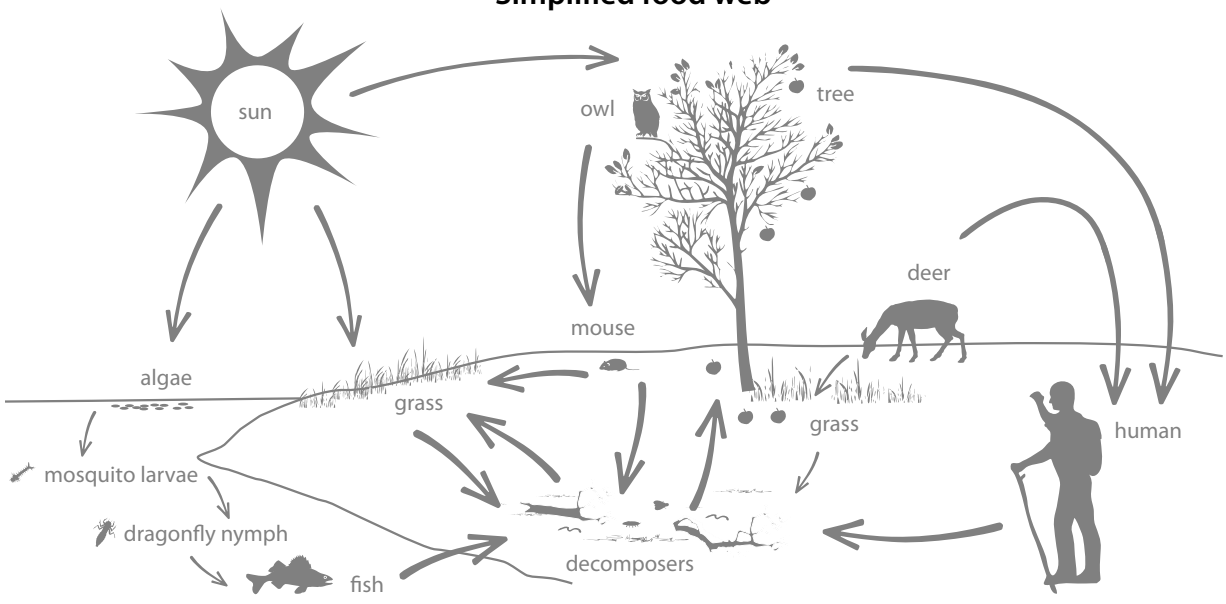
Producer: grass (produces energy from the sun and nutrients)

Consumer: deer (eats grass)

Decomposer: worms (eats deer, creates nutrients from which grasses can grow).

The sun provides energy to the forest. Trees and other plants (producers) use photosynthesis to

Simplified food web



Several food chains linked together are known as a food web. Plants capture energy from the sun, but plants, animals, and decomposers move energy from individual to individual in an intricate web of relationships.

transform the sun's energy into glucose (sugars). Consumers—plant-eating animals such as caterpillars, chickadees, and deer, and animal-eating predators such as coyotes, woodpeckers, and spiders—get their energy from other living things. Decomposers such as sowbugs, fungi, and bacteria get their energy from dead plants and animals.

Several food chains linked together are known as a food web. Every collection of individuals, connections, or processes that regularly interacts and depends on other individuals, connections, or processes forms a unified whole called a system. While each system depends on all other systems, when change occurs (as it always does), the web adapts and adjusts, flexibly.

Oxygen, carbon dioxide, water, and nitrogen all move in natural cycles through the forest. Along with carbon dioxide (from the air) and water (from the soil), energy from the sun triggers photosynthesis in plants, which produces oxygen. Then, plants and animals use oxygen and ***respire*** carbon dioxide and water. Water cycles from the sky to earth and back again, often after spending days, months, or years cycling through lakes, rivers, groundwater reservoirs, and living things. Nitrogen and other nutrients cycle among soil, water, air, and living things.

As you can see, numerous cycles overlap and depend on each other to keep in balance. Everything in the forest is connected to everything else. That means it is impossible to make a change in just one part of the system. Any alteration, whether intentional or accidental, will have effects that ripple throughout the entire ecosystem.

Layers

Many forests contain several different heights or layers of plants. And, as different animals are often found within each layer, the diversity of animals is often related to plant diversity in the forest.

Imagine, for a moment, standing in a sun-filtered stand of mature aspen interspersed with a few white and red pines, remnants of the great northern forest that once stretched across the brow of Minnesota. Some 60 feet (18 meters) above you, resides the top layer, or ***canopy,*** of the forest.

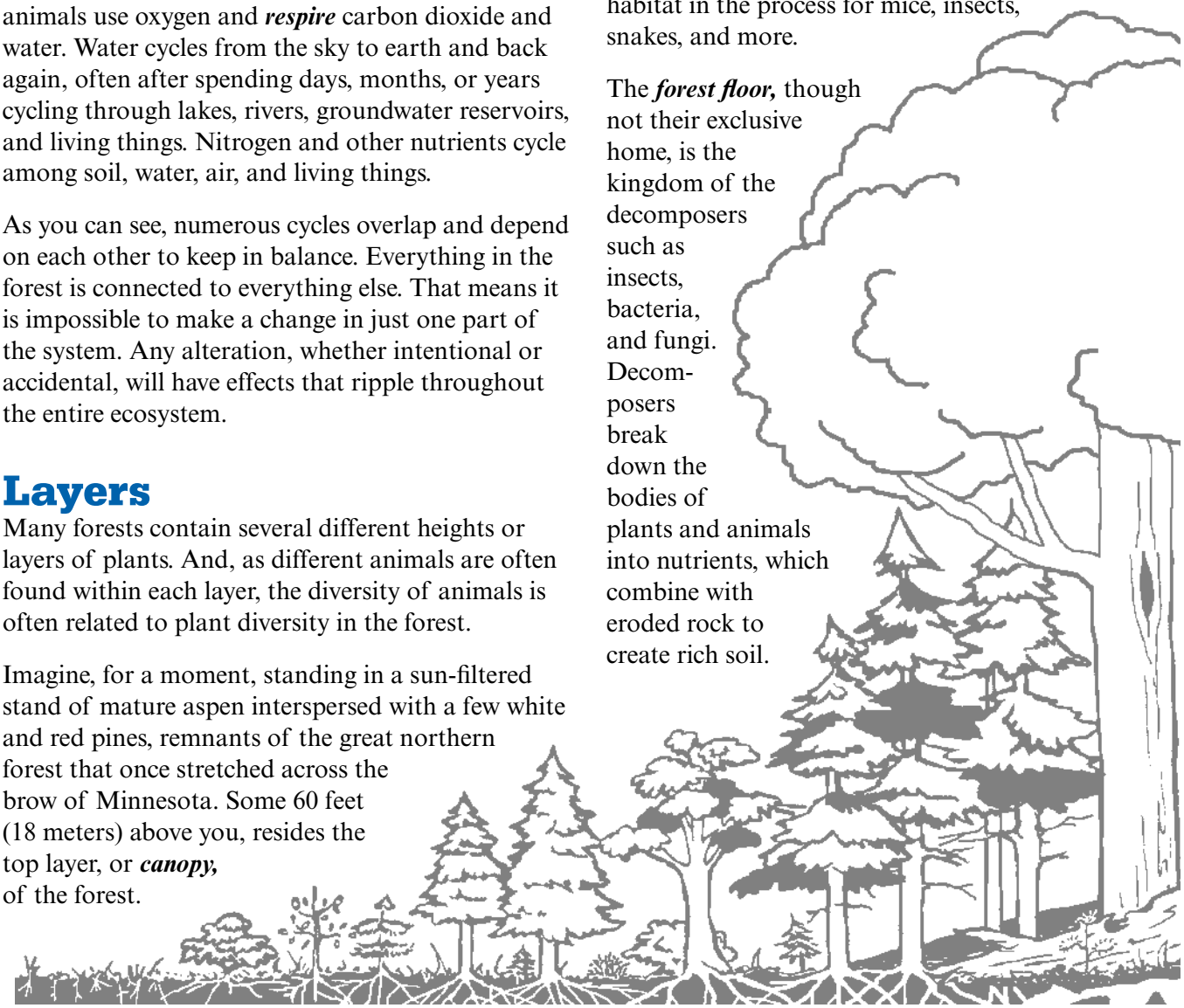
The canopy contains literally millions of leaves busily photosynthesizing sunlight, carbon dioxide, and water to create oxygen and sugar. In turn, all organisms depend on oxygen and sugar for survival. Some of the animals that dwell in the canopy include eagles, bats, and insects.

In the ***understory,*** where the tops of smaller trees absorb whatever sunlight reaches them, a variety of birds and smaller mammals such as warblers and red squirrels eat their suppers and make their nests.

Beneath that, in the head-high ***shrub layer*** made up of saplings and smaller woody plants such as alder and chokecherry, berries and berry-eaters abound. Also in the shrub layer reside browsers such as white-tailed deer, black flies, and mosquitoes.

Even lower, in the ***herb layer,*** seedlings, grasses, and ***forbs***—nonwoody plants such as ferns, sedges, and wildflowers—live and die, providing food and habitat in the process for mice, insects, snakes, and more.

The ***forest floor,*** though not their exclusive home, is the kingdom of the decomposers such as insects, bacteria, and fungi. Decomposers break down the bodies of plants and animals into nutrients, which combine with eroded rock to create rich soil.



This soil in turn provides the nutrients and moisture that trees and other plants need to thrive—and the cycle begins again.

What Lives in the Forest?

The animals of Minnesota's forests come in many sizes and shapes, from tiny mites that inhabit the soil to towering moose and bulky bears. Same with plants, which can be as minute as mosses or lichen or as large as giant oaks. They all have one thing in common: they all rely on the forest setting, or ***habitat,*** for food, water, shelter, and space.

Some animals and plants are adapted to very narrow ranges of conditions in which they are able to live. These animals are called ***specialists.*** The Canada lynx, for instance, needs large tracts of relatively undeveloped forests for hunting. If roads or development fragment a forest, the reclusive lynx may not be able to roam through all of its territory, limiting its ability to access food, water, shelter, or a mate.

Carrol Henderson, Minnesota DNR

About 75 percent of the diet of Canada lynxes is snowshoe hares. Both live in forests.

Ricky Layson, courtesy USFWS

Raccoons eat a range of different foods and therefore can live in a wide range of areas.

Other forest inhabitants, called ***generalists,*** thrive in a wide range of habitat types. One such creature is the highly adaptable raccoon, which is as much at home lunching in an urban trash can as it is in foraging for frogs, ants, fruit, nuts, and fish in a northern stream.

Animal Populations

The number and diversity of animal species depends on the amount of available food, predators, access to clean water, and ability to adapt to changes in food, water, shelter, or space. Some animals such as deer, moose, rabbits, and insects use a broad number of plant species. For example, insects such as mosquitoes feed on a broad range of animals, so removing one species of mammal won't affect the mosquito population. Other animals (like the Canada lynx) subsist only on a narrow range of food sources (like hares). If predators like Canada lynxes are reduced because of over-hunting, over-trapping, or human development, then the population of hares may rise, along with a rise in damage to trees and plants from browsing. In the same way, monarch caterpillars feed almost exclusively on milkweed plants; if milkweeds are removed, so too go the caterpillars.

If confined to too-small habitats, animals (wild or domestic) can overgraze tasty trees and plants and limit those plants' ability to regenerate. Consequently, thorny and less nutritious plants such as the black locust tree and burdock may increase in number. Plants that tend to increase when grazing rises are called ***increasers.*** Plants that tend to decrease as grazing increases are called ***decreasers.*** While many consider increasers "weeds," some increasers do provide benefits. For example, goldfinches prefer to live and nest near large populations of prickly thistles, a plant that increases with grazing and disturbance.

Trout, which prefer clean, cool streams, depend on large, mature trees to shade and cool the water and the gravel streambeds trout lay their eggs in. Trout rely on roots from plants and trees to hold soil in place, preventing streams from filling with silt.

Finally, insects can cause environmental changes. Invasive gypsy moth caterpillars defoliate and weaken certain species of trees, which can change the composition of the forest. Invasive emerald ash borer beetles bore through bark and kill forests of closely growing ash trees.

Different types of forest—and even different parts of the same forest—provide different necessities. The forest floor is by far the busiest part of the forest, with more kinds of plants and animals than any other part of the forest. Animal and plant life is usually most varied where the habitat is most diverse. Some of the richest habitat, for instance, occurs between areas of different types of forests and at forest edges where trees and open areas meet.

Forest Succession

Plant communities change depending on their environmental conditions. As environmental conditions change, the types of plants that make up the community may also change. This process is called ***succession.*** In a stable community, plants are well suited to the amount of water, nutrients, and sunlight available to them. As the availability of resources changes, conditions may favor a different set of plants, and these plants will become more abundant. This causes a shift in the makeup of the plant community. In effect, the new plants succeed the old, creating a slightly different community.

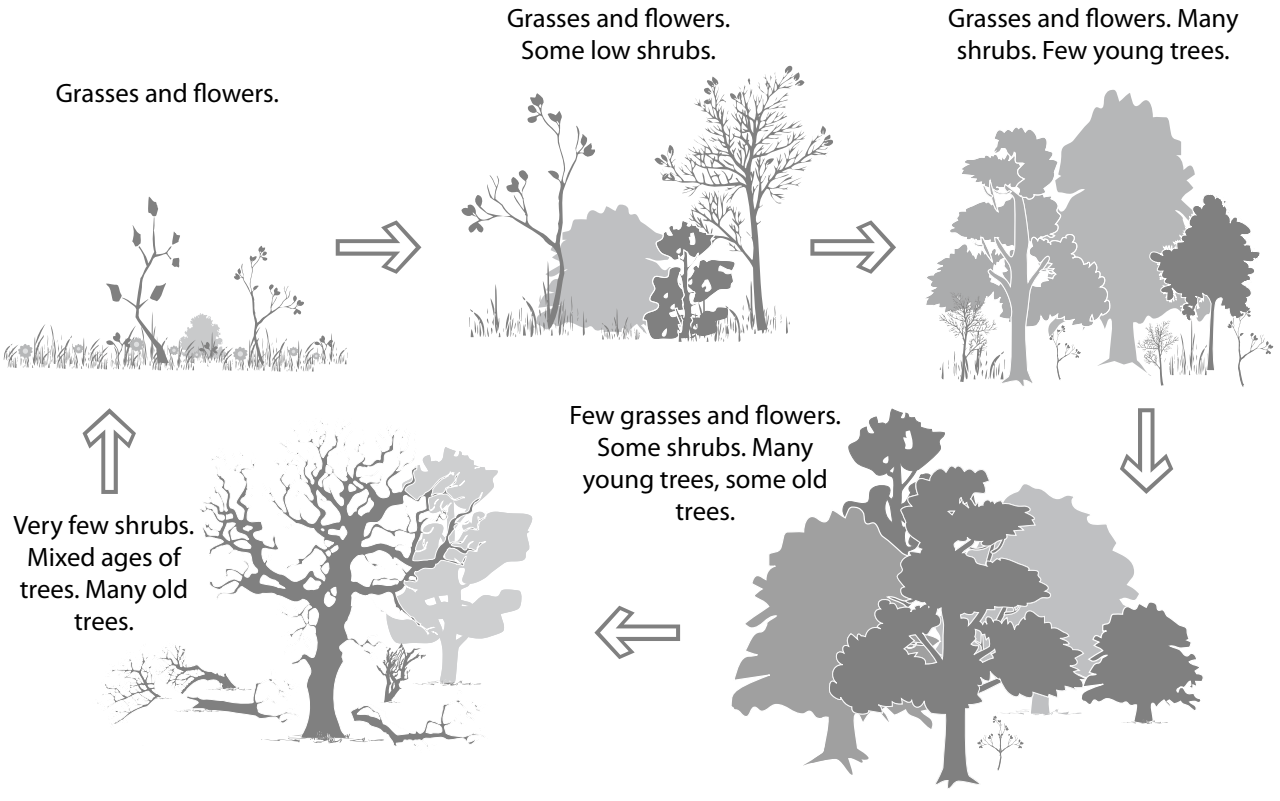
Environmental conditions that trigger succession may include any natural or human-caused disturbance that reduces the number of living trees from an area. Some examples are: timber harvesting, urbanization, farming, fire, and windstorms.

Example 1: From Farm to Forest

A forest growing on abandoned farmland that was once a maple–basswood forest is a good example of succession. After the farmers leave the area, the cleared spaces become friendly terrain for sun-loving, hardy ***pioneer species*** such as grasses, ragweed, and other nonwoody plants. As pioneer species grow and thrive, they often create conditions that favor a second set of plants and animals called ***intermediate species.*** Seeds drifting in from trees that do well in full sun, such as box elder, ash, aspen,

Forest succession: As forests change, so do the number and types of animals that live in them

A disturbance at any of these stages pushes the forest to an earlier stage. Despite periods of stability, forest communities move from one successional stage to another. Throughout history, woodlands have woven their way through many cycles of growth, death, and regeneration urged on by ice, fire, disease, and other disruptions.



and cherry, may repopulate the area. As these trees mature, they shade the forest floor, making it difficult for their own seeds to grow. Shade-loving species such as maple and basswood find themselves at a competitive advantage, and the species composition of the forest slowly shifts. Over time, the older, sun-loving trees die out and the shade-tolerant species take over, creating a ***climax community*** dominated by plants and animals that prefer these conditions. Left undisturbed, the initial climax trees will eventually die, and the forest will evolve into a more stable plant community dominated by maple and basswood until the next disturbance. And the cycle goes on.

Example 2: From Fire to Forest

Fire can also trigger succession. The charred land becomes friendly terrain for the first pioneers—grasses and other nonwoody plants. Raspberry and other shade-intolerant intermediate species such as aspen, paper birch, and jack pine follow. Some of these trees have special adaptations that make it possible for them move into a new clearing. Aspen, for instance, can grow on relatively poor soil and use their root-sprouting capabilities to recolonize a burned forest in a matter of a few years. Jack pine cones are ***serotinous,*** meaning that the seeds stay trapped within the cones until released by heat (120°F/49°C or higher). When a fire burns through an area littered with these cones, they open, scattering seeds on the land. As intermediate species mature, other, more shade-tolerant species—white pine, balsam fir, white spruce, and the like—then find themselves at a competitive advantage, and the species composition of the forest slowly shifts. As the older shade-intolerant trees die out, their more shade-tolerant successors take over, until the next disturbance. And the cycle goes on.

Ham Lake fire in northern Minnesota, 2007.

One month after fire.

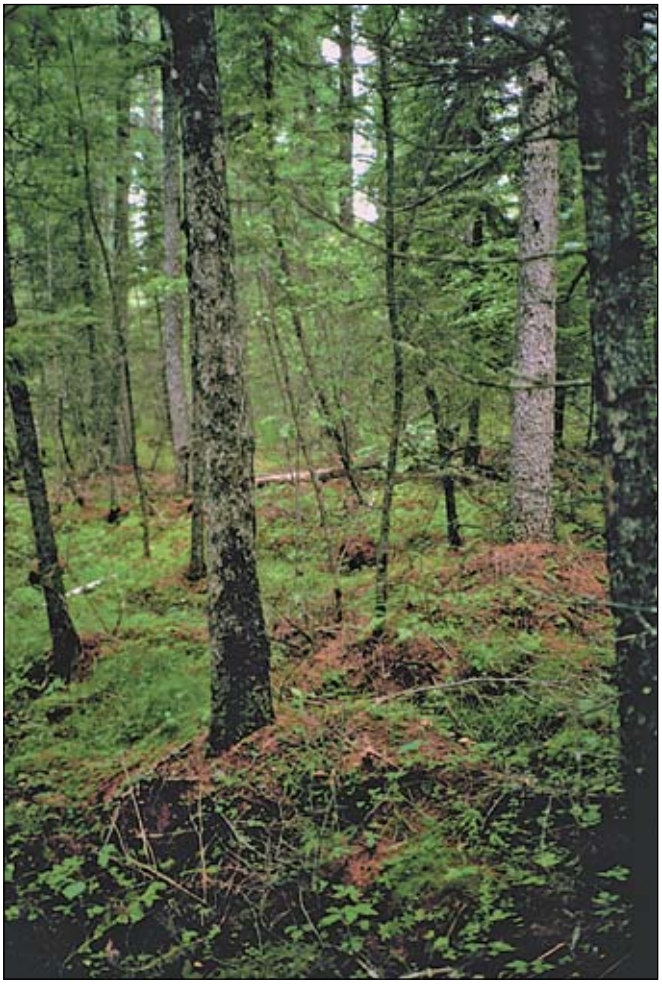
Photos courtesy of Eli Sagor

Native Plant Communities

Because certain trees have similar requirements for light, water, temperature, soil type, and the like, trees tend to appear in predictable combinations. For example, conditions that favor sugar maples also favor the American basswood, so where you find one, you'll likely find the other, along with other plants that thrive in those conditions. Such groups of plants that have evolved and adapted in an area together are called ***native plant communities.*** Native plant communities interact naturally with each other and with their environment and do not contain introduced, or nonnative, plants and communities.

Within native plant communities, forests are named according to the conditions and dominant plants found in that community. There are more than 50 native plant communities in Minnesota. The following table lists some examples of native plant community names and places they can be viewed.

Native Plant Community	Examples of Locations
Central Dry-***Mesic***-Pine-Hardwood Forest	Itasca Wilderness Scientific Natural Area (SNA) Afton State Park
Southern Wet Ash Swamp	King's and Queen's Bluff SNA Nerstrand Big Woods State Park
Northern Terrace Forest	Kettle River SNA St. Croix State Park
Southern Dry ***Savanna***	Helen Allison Savanna SNA Minnesota Valley State Park
Northern Wet-Mesic ***Boreal*** Hardwood-Conifer Forest	Lake Bemidji State Park Scenic State Park Zippel Bay State Park



Minnesota DNR

A northern wet-mesic boreal hardwood-conifer forest.

To sum up

Chapter Two: Forest Ecosystems

- Forests are complex ecosystems that support a range of plants and animals.
- Forests are made up of several layers.
- The kinds of animals in a forest are related to the kinds of plants in the forest, plus other factors such as climate, soils, and landforms.
- Forests are always changing due to disturbances, which may be natural or human-caused.
- When forests change, so do the number and types of plants and animals in them.
- Minnesota forests face threats from invasive plants and animals.