All About Minnesota's Forests and Trees: A Primer




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Who Should Read This Book?

This book is written for those of us who care about trees and forests and who want to share our knowledge with others. With a little motivation, each one of us can teach about trees, care for trees, and establish a legacy of trees around our schools, homes, and communities. Please share what you learn with students, neighbors, community leaders, and others who care for trees and forests.

How This Book Is Organized

This book is a "primer," which means every topic and new word builds on a topic or word introduced earlier. The first two chapters introduce the basics about trees and forests; chapters three through six discuss people's interactions with trees—past, present, and into the future. Several appendices are provided to give the reader more in-depth information.

Words in ***bold italics*** are defined in the glossary.

To exist as a nation, to prosper as a state, and to live as a people, we must have trees.
—Theodore Roosevelt, United States President, 1901–1909

PREFACE WHY SHOULD WE CARE ABOUT TREES?

You've probably enjoyed a hike through a sun-dappled hardwood forest, or the sight of a tree outside your window. You've undoubtedly used tree-based products and breathed tree-manufactured oxygen. But does that mean you ought to spend time thinking about trees and forests, too?

YES!

Think about your morning breakfast. Your kitchen may contain wooden cabinets, utensils, flooring, furniture, countertops, and walls. The glue holding together wood veneer contains resins from trees. Orange juice, apples, maple syrup, vanilla, and nuts come from trees. Your morning paper contains a mix of new and recycled wood fibers. The energy company powering your toaster may draw that power from burning wood chips or other biomass. What would your breakfast be without trees?

Trees and forests enrich our lives in an amazing number of ways. They provide beauty and shade, recreation opportunities, and habitat. They absorb carbon dioxide and make oxygen, provide shelter and shade. They help keep lakes, streams, and other waterways clean by holding soil in its place.

Best of all, trees are renewable. That means we can use resources like trees indefinitely because we can always grow more of them. But we must do this with care, to ensure that future generations can benefit from trees, too.

The notion of "care" is where knowledge comes in. To care for something, we must recognize how it lives and dies, its worth, and its needs. The purpose of this primer is to provide Minnesotans with these two gifts: a sense of the complexity and value of trees and forests, and an introduction to what it takes to keep this resource renewable.

After reading this primer, we hope you will take to heart a sense of stewardship for trees, and for all natural resources, so we, and future generations, may enjoy the forests of today and tomorrow.

The Tree stands in triumph with its roots deep in the Earth, its branches touching the Sky, its leaves capturing the Sun and breathing the breath of life for animals and Man—the keystone of our natural environment and the symbol of man's life and consciousness.
—Marion T. Hall, The Morton Arboretum

CHAPTER ONE TREE BASICS

What do you think of when you hear the word *tree?*

Did you think of a sprawling oak or a newly planted ash that grew outside your grade-school classroom? Maybe your image is one of pines towering above your head on a needle-padded hike, or of fresh green aspen lining the shore of a northern lake, or a glowing maple whose changing colors mark the coming of frost and football. Your thoughts might even turn to trees transformed—to the chair in which you sit, the crisp apples of autumn, the floor beneath your feet, the paper on which these words rest.

Whatever specific images come to your own mind, one point is common to all Minnesotans: the trees of our state hold a treasured place in our memories, in the moments we are living today, and in our futures. Rooted to the ground, they provide a sense of beauty and timelessness. Sensibly harvested, they provide a natural, renewable source of goods for everyday living. Managed with wisdom and a sense of stewardship, trees are the ultimate gifts that keep on giving.

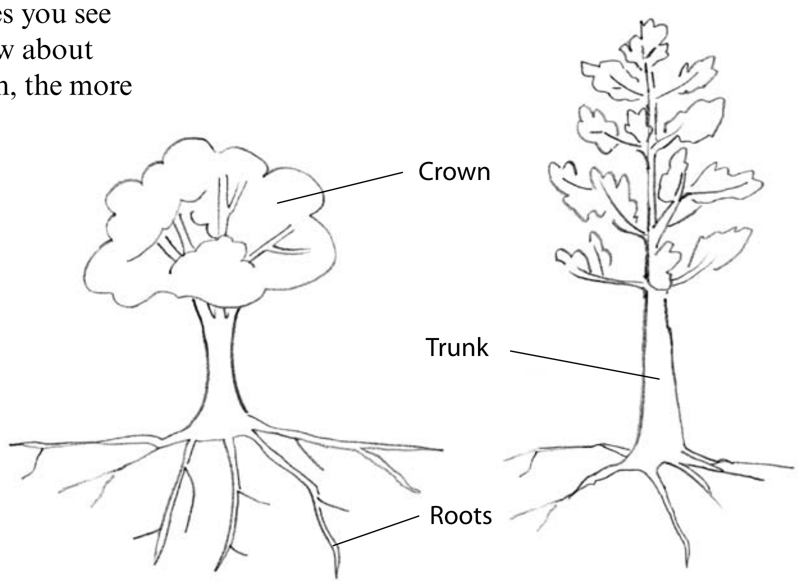
The more you learn to appreciate the trees you see around you, the more you'll want to know about them. And the more you know about them, the more you'll appreciate them!

Anatomy of a Tree

Trees are defined as woody plants that can reach a height of 15 feet (4.6 meters) or more at maturity, are usually single stemmed, and have a branched-out area at the top. This distinguishes trees from shrubs, which are woody but short and multistemmed, and from vines, which may be long and woody, but cannot support themselves and lack a branching top.

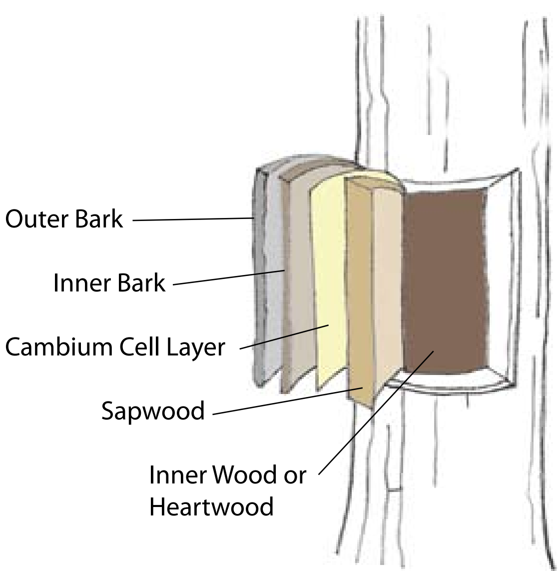
Trees have three major parts: crown, trunk, and roots.

The ***crown*** consists of branches and leaves. Cells in the leaves convert sunlight, water, and carbon dioxide into sugar ***(glucose)*** in a process called ***photosynthesis***. Trees use the glucose to make wood, leaves, seeds, and other plant parts. Trees with large crowns have more leaves and generally grow faster than trees with small crowns. In some trees, such as box elders, cells in the twigs and branches also photosynthesize. These twigs usually appear greenish. The tree's crown also is home to flowers, fruits, and seeds, all of which play a part in reproduction.



Three types of cells make up the ***trunk.*** In turn, the trunk is made up of several layers, each with a specific function.

1. ***Xylem*** cells make up the bulk of the trunk and the annual rings. Xylem cells move water and nutrients between the roots and the leaves.
    - ***Inner wood*** or ***Heartwood*** consists of dead xylem cells and leftover darker chemical compounds that are the products of decomposition. It is found in the center of a tree. It functions to provide strength and support as the tree grows.
    - ***Sapwood*** consists of layers of living xylem cells. As these cells age and die, they become inner wood.
2. ***Cambium*** cells reside in a very thin layer between the xylem and phloem. Each year, cambium makes a new layer of xylem cells inward and a thin layer of phloem cells outward. The cambium layer is only a few cells thick and can only be seen with a microscope.
3. ***Phloem*** cells move sugar and other substances between the leaves and the roots.
    - ***Inner bark*** is made of live phloem cells and is rich with nutrients. Inner bark stays alive and active for only one year, and then becomes outer bark.
    - ***Outer bark*** is made up of dead phloem cells. It protects the tree.



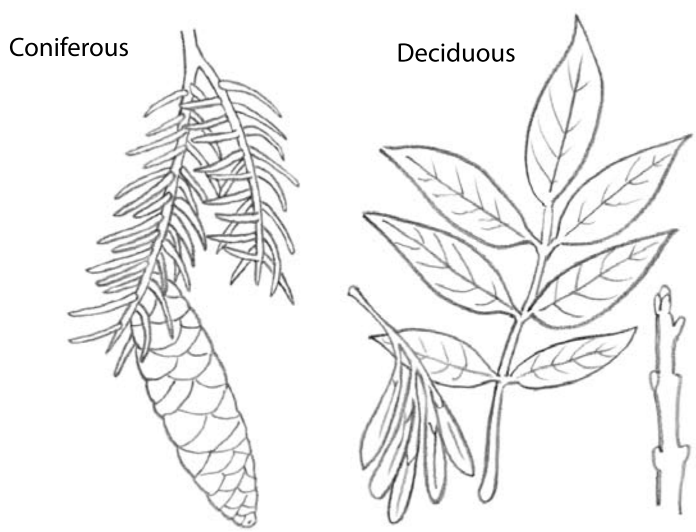
The ***roots*** anchor a tree in the soil. Roots also take up water and nutrients, such as phosphorus and nitrogen, which a tree needs to grow. In some species, such as aspen, roots play a part in making new trees. Shapes and locations of tree roots vary by species and growing conditions. Roots may be thinner than a human hair or as big around as a telephone pole. Some trees, such as some oaks, have a large ***taproot*** that extends straight down from the trunk, from which smaller roots extend. In other species, roots fan out broadly and stay closer to the surface of the soil. Aspen roots, for instance, may stretch 60 feet (18 meters) or more from the base of the tree. Roots may take up four to seven times the amount of space covered by the crown of the tree. Ninety-nine percent of the roots of most trees are in the top three feet (0.9 meters) of the soil.

Two Types of Trees

Trees are often divided into two groups: ***coniferous*** and ***deciduous***.

Coniferous trees ***(conifers)*** protect their seeds in cones and do not produce fruit. Coniferous trees have needlelike or scaly leaves that are shed as the leaves age and not all at once. Because most coniferous trees retain some green leaves all year, they are also known as "evergreens." Conifers may also be referred to as needleleaf trees, or softwoods.

Deciduous trees shed their leaves each fall and grow new leaves each spring from buds created in the previous year's growing season. Their seeds are covered and come in several forms, such as winged maple seeds, nuts, and berries. Deciduous trees are also called ***broadleaf*** trees, or hardwoods.



Trees Through the Seasons

Spring, summer, fall, winter … each season provides trees with unique challenges and opportunities.

Spring

As the air warms in spring, sap rises from the roots, carrying nourishment to the branches. Coniferous trees develop new shoots that expand to form new stems and needles. On deciduous trees, buds swell and open into new shoots and leaves. Conifer buds also swell and flush out in the spring.

Although trees grow throughout their lives, spring is an especially rich time for fast growth.

Growing Tall

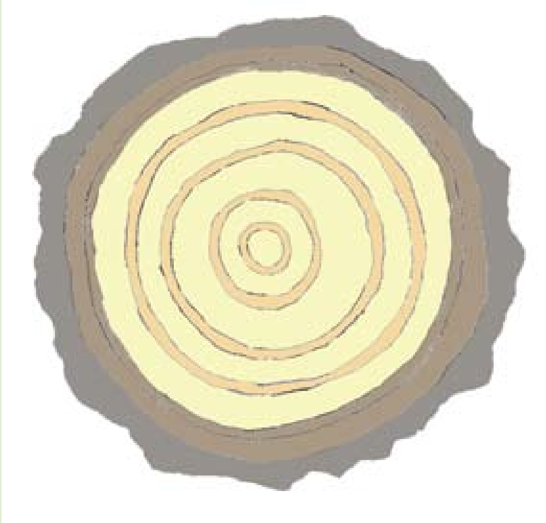
In spring, new tissue is added at ends of twigs. Leaves form as buds open and grow. Trees grow taller from the ends of their twigs, not from their trunks. If you were to drive a nail into a sapling and come back in 30 years, the nail would still be the same distance from the ground and probably completely embedded into the tree!

Growing Fat

Each year, trunks and branches grow wider and thicker. If you look at a cross section of trunk, you can see a history of the tree's growth through its annual rings. Rapid growth during springtime creates many xylem cells, which make a light-colored wood known as ***spring wood.*** As tree growth slows during the hot, dry summer, fewer new xylem cells are laid more slowly and produce a darker circle of wood. This is often called ***summer wood.*** One layer of light-colored spring wood along with one layer of darker summer wood marks the passage of a year in the tree's life.

Growing Underground

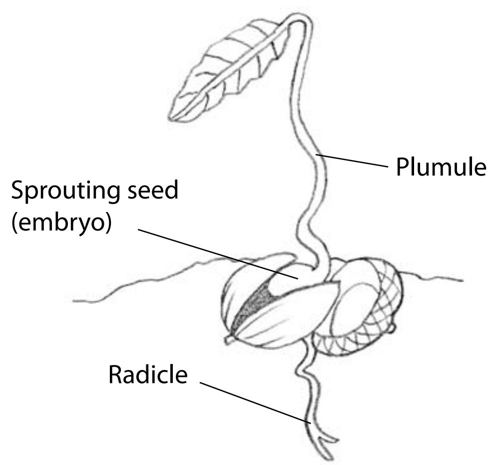
Finally, each year roots grow deeper and broader beneath the earth as root tips grow and branch.



The light rings show wood that grew in the spring, and the dark rings show wood that grew in the summer. Examining tree rings can tell a story of how that tree grew over its lifetime, recording years of vigorous or weak growth, damage from fire or insects, or competition from other trees. Appendix 3 contains drawings of common tree stories told by the trees themselves.

Summer

Many trees ***germinate*** in the summer. Sunlight and moisture send the seed signals to begin to sprout. Water softens the seed shell (coat) and expands the food, called ***endosperm,*** inside. The new plant, or ***embryo,*** uses energy from the endosperm to push a stem ***(plumule)*** up toward the sunlight and to push a root ***(radicle)*** down into the soil.



Sugar From Sunshine

Trees use a process called ***photosynthesis*** to manufacture a type of sugar called ***glucose*** from the sun. ***Chlorophyll*** and other pigments in the leaf transform carbon dioxide (CO_2) and water (H_2O) into oxygen (O_2) and sugar ($C_6H_{12}O_6$):

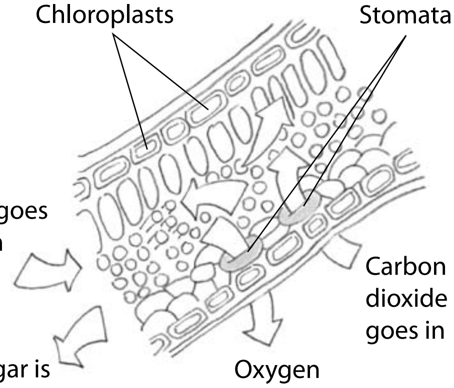
$6CO_2 + 12H_2O$ through the process of sunlight/chlorophyll turn into $6O_2 + C_6H_{12}O_6 + 6H_2O$.

Chlorophyll and other pigments absorb energy from the sun. They are found in green, microscopic structures called ***chloroplasts,*** which are within cells.

The tree takes in carbon dioxide through small holes in its leaves called stomata (singular: ***stoma***).

Using the energy from the sun, trees combine carbon dioxide with water, drawn up from the roots, to make sugar and oxygen. The tree uses sugar to grow. It releases oxygen, a byproduct, to the air.

Cross section of a leaf



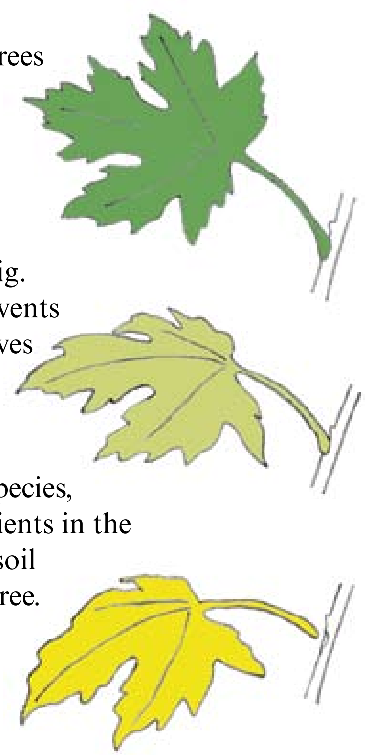
All of Earth's oxygen is produced by photosynthesis.

Fall

The cool nights and shorter days of autumn signal deciduous trees to shut down the process of photosynthesis. When photosynthesis stops, the green chlorophyll pigments become less vibrant. Then, yellow, orange, and brown pigments called ***carotenoids*** that were hidden by summer's green chlorophyll begin to show. Red, purple, and crimson ***anthocyanin*** pigments also appear. The leaves of most coniferous trees stay green, because their hard, waxy needles prevent them from drying out and the chlorophyll within can continue to photosynthesize all winter long. However, less sugar is created in the winter because of shorter periods of and less intense sunlight due to the lower angle of the sun.

Carotenoids give color to carrots, corn, canaries, daffodils, egg yolks, rutabagas, buttercups, and bananas, as well as tree leaves.

Also in fall, deciduous trees produce a hormone called ***abscisic acid,*** which forms a corky membrane called an ***abscission layer*** between the leaf and twig. The abscission layer prevents sugars created in the leaves from entering the woody parts of the tree. The leaf then separates from the tree. In some species, much of the stored nutrients in the leaf are dropped to the soil around the base of the tree. In other species, leaves move nutrients from the leaf into the stem before abscission.



Ever notice how some dried oak leaves seem to persist on twigs through the winter? That's because in oak leaves, the abscission layer fails to form all the way through the leaf stem in the fall. Instead, oaks undergo a second phase of leaf drop (abscission) in the spring just before bud-break. No one knows why oak trees keep tight hold of dead leaves through winter, but it's an interesting observation.

Weather and Fall Colors

Fall colors are related to temperature and moisture conditions before and during the time when chlorophyll in the leaves dwindles away. Sunny, warm days cause leaves to produce a lot of sugar, and cool evenings prevent the sugars from moving into the trunk and roots. As a result, a succession of warm, sunny days and cool, but not freezing, nights seems to contribute to a good fall color season. These kinds of fall days produce the most anthocyanin pigments—red, purple, and crimson. Carotenoids are always present in leaves, so yellow and gold colors are fairly constant each year.

Late springs and severe summer droughts can delay the onset of fall color by a few weeks. A warm, wet spring, followed by a summer of adequate moisture, then warm fall days with cool nights, seems to bring on the best colors.

Leaves to Life

The health of a forest depends on the nutrients that come from the leaves and needles that fall to the forest floor. The leaves decay to create ***humus,*** a spongy, nutrient-rich material. Humus (similar to ***duff***) becomes an important part of the soil that holds in moisture and provides food for living things, such as microorganisms, herbs, grasses, ferns, shrubs, trees, and insects.

Fall is also the time when the living tissues in the tree's trunk and branches begin a process called ***hardening,*** a gradual acclimatization to cold conditions, which prepares them for winter. Triggered by cooler and shorter days, hardening enables a tree to survive cold weather. If a tree were suddenly exposed to winter temperatures in July, it would be injured or die. But after it's gone through hardening, a tree can survive temperatures far below freezing.

Winter

In the winter, trees continue to harden. To understand hardening, it helps to know what frostbite is. Whether in people or in pines, it is the damage caused when the liquid within individual living cells freezes. As the liquid freezes, it expands, destroying the cells in the same way freezing soda will demolish the bottle or can it's sealed in.

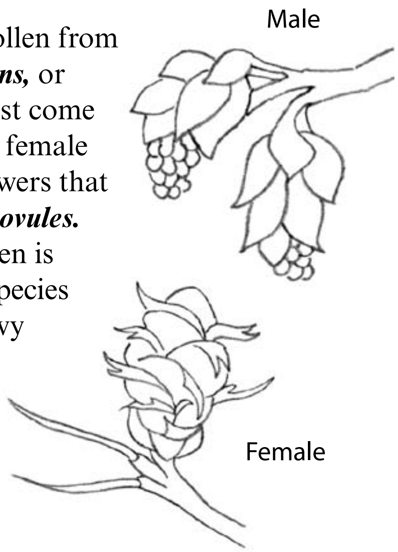
Trees avoid frostbite in two ways. One is called ***supercooling.*** Some trees count on supercooling to survive, which relies on the fact that liquids can form crystals if they have a starting place, called a nucleus, for crystals to grow. If there is no nucleus, the liquid inside tree cells will continue to cool below its normal freezing point but will not actually turn into a solid—at least down to about –40°F (–40°C). Some trees, such as red oaks, keep their cellular liquids free of crystal-forming nuclei and so are able to survive to these low temperatures without tissue damage.

In some places, it gets colder than –40°F (–40°C). Trees that live in these conditions are able to use a technique called ***extracellular freezing.*** Here, liquids within cells seep out into the spaces between the cells, where they can freeze without harming plant tissue. This is why trees like black spruce, balsam fir, and quaking aspen can survive in temperatures as low as –100°F (–73°C)!

How Trees Reproduce

Trees reproduce in a variety of ways. Most deciduous trees form flowers in spring. In ***monoecious*** species like maples and birches, each flower has both male and female parts or, separate male and female flowers appear on the same tree. ***Dioecious*** trees like aspens develop male and female flowers on separate trees. Coniferous trees do not produce true flowers but have male and female cones that are sometimes called flowers. Male cones fall off after they release their pollen; female cones persist to develop seeds. Depending on the species, the male and female cones may be on the same (monecious) or on different (dioecious) trees.

For seeds to form, pollen from the male cones, ***catkins,*** or ***staminate*** flowers must come into contact with the female cones or ***pistillate*** flowers that contain tiny egg-like ***ovules.*** In many species, pollen is carried by wind. In species with fragrant or showy flowers, pollen may be carried by insects. The pollen and ovules join to make a new seed.



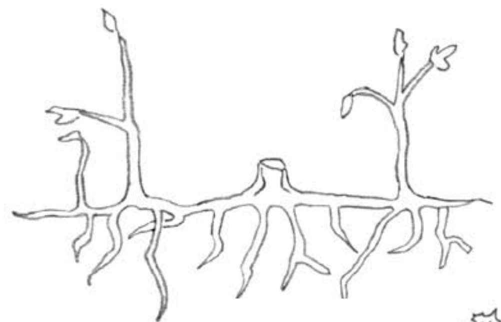
Tree seeds are distributed in various ways. Wind carries seeds that are small, fluffy, lightweight, or have wings (samaras). Birds, mammals, and people spread seeds hidden in fruits, nuts, and cones. Water and gravity also carry seeds away from the parent tree.

Methods of seed dispersal:

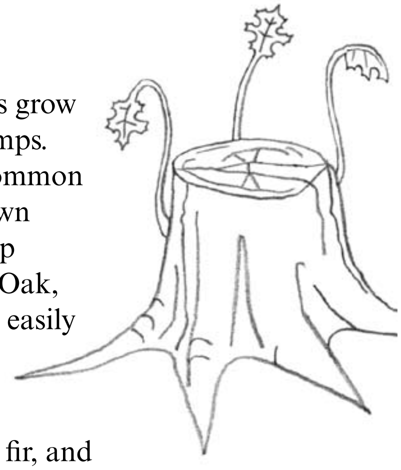
- Floats on air (cottonwood, aspen, red pine)
- Flies through air (maple, ash)
- Stored or eaten and excreted by animals (oak, cherry, pine nuts)
- Bounces or rolls (oaks, walnut)
- Released or opened by fire (jack pine)

A new tree is called a ***seedling*** if it grows from a seed. Seedlings are unique individuals because they contain a new combination of genetic material produced from the merger of pollen and eggs.

If a new tree grows from the roots of another tree, it's a ***sucker.*** Aspen often reproduce by ***suckering,*** a process by which roots send up shoots that break through the surface. As a result, aspen can cover a large area soon after trees are harvested.



Some deciduous trees grow new trunks from stumps. ***Stump sprouting*** is common when a tree is cut down or dies, and the stump remains to resprout. Oak, maple, and birch will easily stump sprout.



Some trees, such as black spruce, balsam fir, and white cedar, can reproduce through ***layering,*** a process in which a branch touching the ground takes root and forms a new plant.

Suckers, stump sprouts, and trees that grow from layering are all ***clones*** of the parent tree, which contain the same genetic material.

When a seedling, sucker, or sprout reaches a height of about 6 feet and a trunk diameter of at least 1 inch but less than 5 inches at 4½ feet from the ground, it is called a ***sapling.***

Where Trees Grow

Each species of tree has unique characteristics that allow it to grow and thrive best under a given set of conditions—sunlight, moisture, slope, temperature, soil type, and so forth.

Sunlight and Shade

Shade tolerance—the amount of shade a tree or seedling receives—affects how well it will grow. ***Shade-intolerant*** species such as aspen need direct light to thrive and are more likely to be found in an open area than growing beneath taller trees. Shade-intolerant species include aspen, black ash, paper birch, tamarack, red pine, black walnut, bitternut hickory, and jack pine. ***Shade-tolerant*** species grow readily in the shadows of other trees. Examples are red maple, balsam fir, sugar maple, black spruce, and American basswood. ***Intermediately shade-tolerant*** species can tolerate some shade and some sun. Examples include white spruce, bur oak, American elm, and white pine.

Moisture and Flooding

Trees tolerate the amount and timing of moisture differently. Some trees such as silver maples and cottonwoods have adapted to seasonal floods—periods of time when water saturates the soil and roots for more than a week. Trees with extensive root systems (such as willows) are structurally more able to withstand soils weakened by floods. Other species, such as red and sugar maples, require well-drained soils, while species such as northern white cedar prefer low and wet areas.

Slope and Landforms

Bottomlands are low areas with little or no slope and often contain more rich, moist soils than upland areas. The steeper the slope, the more well-drained the site is. Nearby landforms like hills, valleys, lakes, and mountains may funnel drying winds, or trap moisture, depending on their location.

Aspect and Temperature

South- and west-facing slopes receive more heat and sunlight. Because south- and west-facing slopes get their sunlight during the hotter parts of the day, more moisture is lost than if they received their sunlight during the cooler morning. Also, south- and west-facing slopes are windier during the growing season.

North- and east-facing slopes receive less heat, sunlight, and wind than their south- and west-facing counterparts. East-facing slopes receive sunlight during the cooler morning hours and therefore retain a little more moisture.

Soil

Soils consist of parent and organic material. Parent material comes from the original rock (such as limestone or basalt) that has been weathered down to make smaller particles. Organic material comes from decaying plants and animals. Soils with more organic content contain more nutrients and microorganisms. Soil texture is also categorized accordingly—fine-grained clay, medium-grained silt, and coarse-grained sand. Most of the time, soil contains a mixture of two or three categories, and is called ***loam.***

Below are examples of typical conditions in which three tree species thrive.

Species Name	Tolerance to Shade	Tolerance to Flooding	Preferred Slope and Aspect	Preferred Soil
Green ash 	High	High	Bottomlands	Medium- to coarse-textured sand and loam soils
Bur oak 	Intermediate to low	Moderate	North- and east-facing gentle slopes	Moderately deep (20 to 36 inches or 50 to 92 centimeters) sandy to loam soils
Red pine 	Low	Low	Uplands	Well-drained (but not dry) sandy to loamy soils

Minnesota Natives

A ***native*** tree is one that has evolved in and adapted to an area over several thousand years without help from humans. A ***nonnative*** tree is a tree planted or introduced by humans. Minnesota is home to 52 native species of trees (see Appendix 2).

A ***noninvasive*** tree does not spread prolifically and does not out-compete other plants. Noninvasive trees may be native, like basswood or white pine, or nonnative, such as apple trees and Scotch pine.

An ***invasive*** tree is one that spreads prolifically and may crowd out other plants, greatly reducing the diversity of plants and animals living in an area. Again, invasive trees can be native, like box elder or honeylocust, or nonnative, like Norway maple or buckthorn. Some invasive trees, like wildlife-friendly aspen, can be beneficial. In many cases, aspen took over when Minnesota's northern pinelands were extensively harvested at the turn of the last century. Other invasive trees, like buckthorn and black locust, can severely damage ecological health by crowding out species that support better habitat for wildlife. Common invasive, nonnative trees found in Minnesota include: black locust, buckthorn, Norway maple, Amur maple, Siberian elm, and Russian olive.

When determining whether a tree is native or nonnative, it helps to be able to identify the tree. The first step is learning what to look for. Here are some characteristics people use to identify trees:

- Location (country; state; proximity to rivers, wetlands, and hilltops; climate, etc.)
- Type (coniferous, deciduous)
- Leaves (shape, arrangement, size, texture)
- Bark (color, shape, texture)
- Twigs (branching patterns, bud-scale scars)
- Seeds (type, size, color)
- Flowers (number of petals, color)
- Fruit (type, color, taste)
- Shape (of trunk and crown)
- Size (height and girth)

Tree identification guides often use ***dichotomous keys*** to help you identify trees. The key asks questions about the tree you are looking at, and leads you down an ever-narrowing path of possible tree types that match the tree's features. With the help of a good tree identification guide, you can become an expert at identifying Minnesota trees. Identification guides for trees in Minnesota are listed on page 51.

Minnesota's Biggest Trees

Minnesota's biggest 52 native tree species are listed in the Big Tree Registry. Nominees are judged on three measurements: the circumference of its trunk 4½ feet above the ground, its height, and one-quarter of its crown spread. The total of these measurements is the points awarded to that particular tree. A champion is one that has accumulated the most points. If two trees of the same species have identical scores, the tree with the largest trunk circumference becomes champion.


Paul Sunberg, Minnesota DNR

Everyone is invited to join the search for Minnesota's champion big trees. Learn how to measure trees in Appendix 4.

To sum up

Chapter One: Tree Basics

- Trees have three parts: crown, trunk, and roots.
- The trunk is made of three types of cells: xylem (inner wood, sapwood), cambium, and phloem (inner bark, outer bark).
- There are two types of trees: coniferous and deciduous.
- Trees grow up, out, and down (through the roots).
- Trees make energy through the process of photosynthesis.
- Deciduous trees prepare for winter by shedding their leaves.
- In winter, trees undergo the processes of hardening and supercooling to prevent freezing to death.
- Trees reproduce through seeds, suckers, stump sprouts, and layering.
- Different tree species thrive in different growing conditions: sunlight, moisture, slope, aspect, temperature, and soil type.
- Consider whether a tree is native or nonnative when identifying trees.

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:

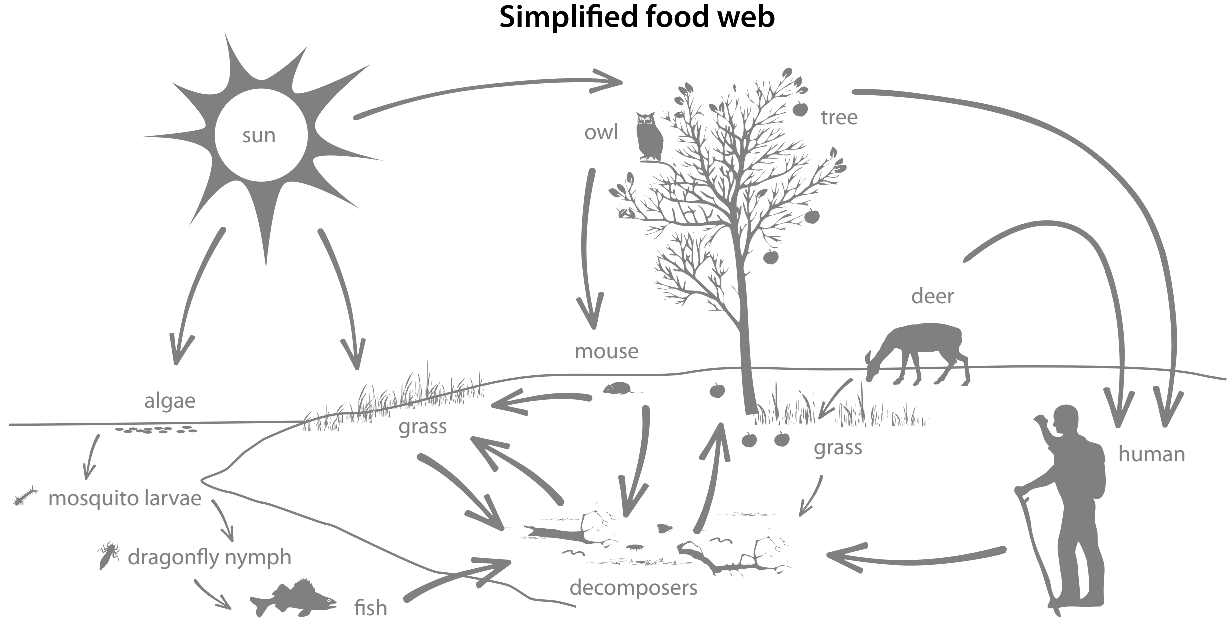
Producers—organisms that produce energy
Consumers—organisms that consume producers and other consumers
Decomposers—organisms that consume producers and consumers, and provide nutrients into the soil.

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.

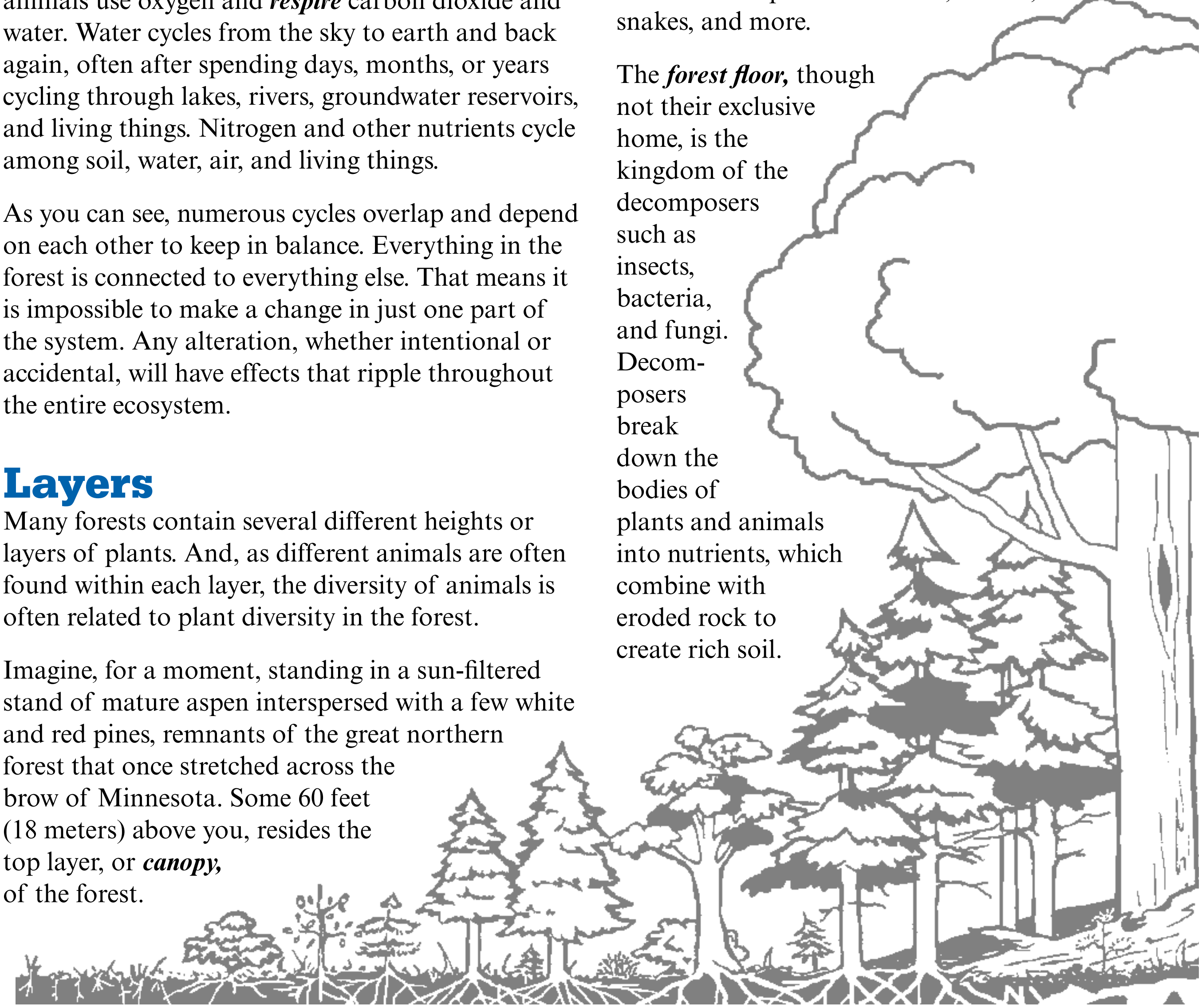
The canopy contains literally millions of leaves busily photosynthesizing sunlight, carbon dioxide, and water to create oxygen and sugar. In turn, all organisms depend on oxygen and sugar for survival. Some of the animals that dwell in the canopy include eagles, bats, and insects.

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.

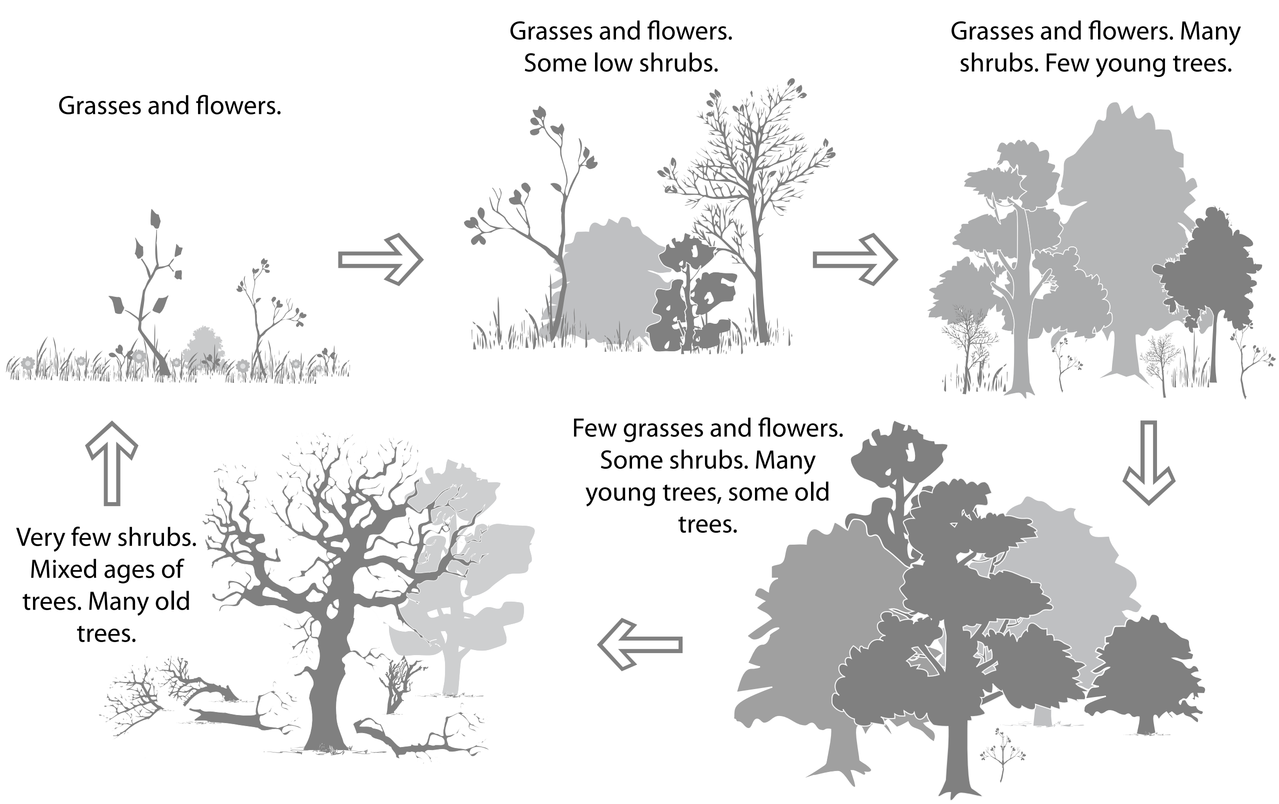
Environmental conditions that trigger succession may include any natural or human-caused disturbance that reduces the number of living trees from an area. Some examples are: timber harvesting, urbanization, farming, fire, and windstorms.

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.

Photos courtesy of Eli Sagor

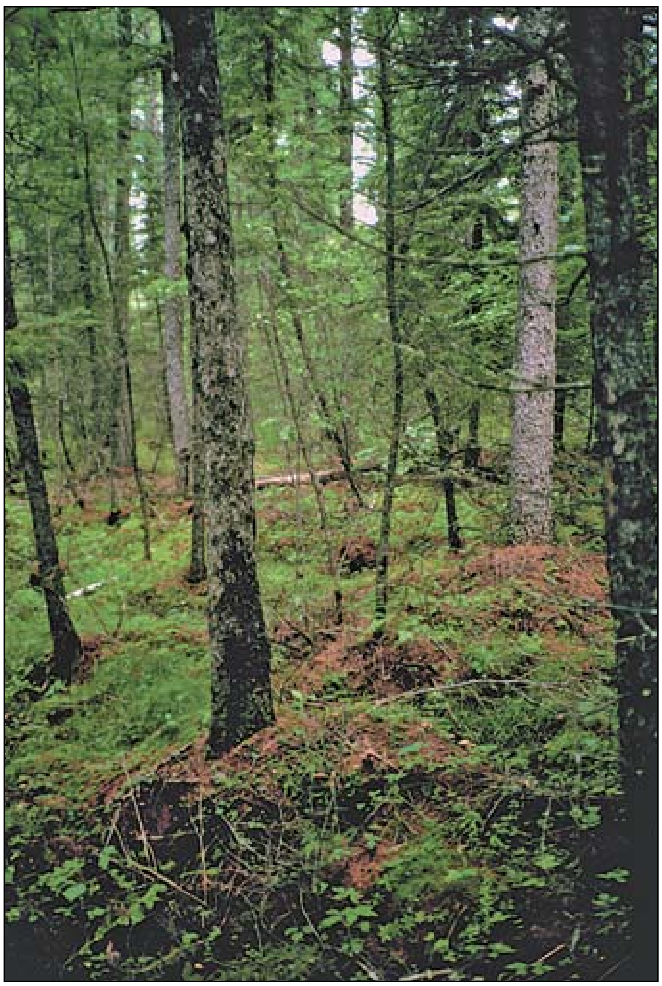
One month after fire.

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.

And see the peaceful trees extend their myriad leaves in leisured dance—
they bear the weight of sky and cloud upon the fountain of their veins.
—Kathleen Raine, from Envoi,
Collected Poems, 1956

CHAPTER THREE FORESTS BEFORE SETTLEMENT (PRE-1800s)

Take a walk through one of Minnesota's many forests and you may likely get the impression that it was a relatively settled place—as though it always had been what it is now. Those towering trees didn't arrive yesterday, it's true...and their staid presence does give the forest a feeling of permanence that farmland and city subdivisions just don't share. Yet even the least disturbed, most "natural" areas of our state have seen many changes through time. Minnesota's forests today are the result of millennia of transformations.

The earliest known modern tree appeared about 350 million years ago. The Archaeopteris, a tree that looked similar to a Christmas tree, had buds, reinforced branch joints, and wood similar to today's timber. Its branches and leaves resembled a fern.

Ice Age Roots

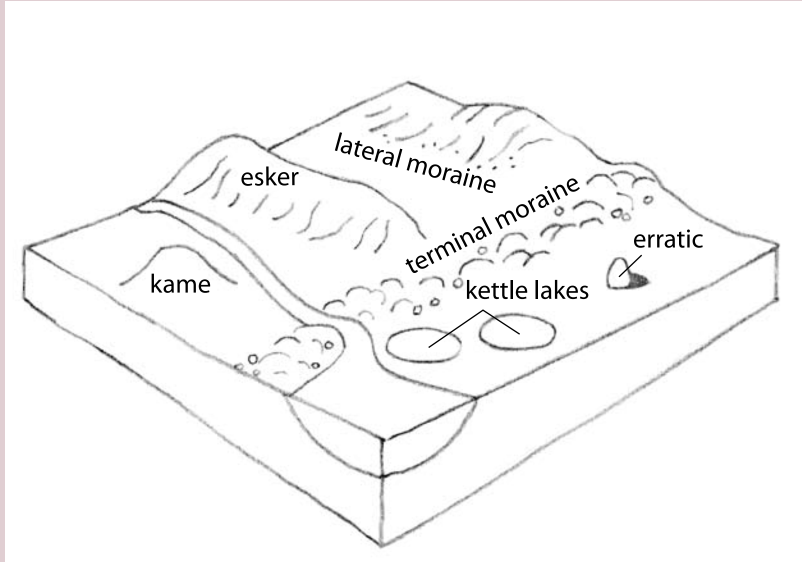
The Minnesota we know today was carved and etched by ice in the form of massive glaciers that periodically crept south from northern latitudes during cold phases of the warming–cooling cycle that has long characterized Earth's climate. Little is known about the vegetation covering the area before the most recent of these glaciers melted, though there is evidence that trees were indeed a part of the landscape even then.

The story of Minnesota's modern forests begins about 10,000 to 20,000 years ago, when the last of the great glaciers began its warming-weather retreat to the north. Some 20,000 years ago, the Wisconsin Glaciation covered all of Minnesota except for the southeastern corner, now known as the "driftless area." As the climate warmed, the massive frozen rivers of ice and snow carved hills, valleys, and plains, and scraped marks into rocks that still tell the tale of their passage.

When we look over the land, we recognize that much of what we see is a mere snapshot of glacial time. As great lobes—curved or rounded projections—of thick ice advanced, retreated, scraped, and dug their ways across the land, glaciers removed much of the topsoil, revealing bedrock. As glaciers receded, they covered the landscape with piles of deposited soil and rock, bumps, hills, holes, and other distinctive Minnesota landforms.

These remnant piles and bumps chose the key and set the meter for the symphony of vegetation that followed the glacier's icy footsteps. By forming the lay of the land and determining the quality of the soil, the glaciers—in concert with weather and climate—largely determined the shape, size, and species composition of the forests that grew under their direction.

Glacial Formations



Glaciers can scour off topsoil and scrape and scar the bedrock beneath. Good examples of glacial ice scrapes and scars on bedrock can be seen at Gooseberry Falls State Park and Palisade Head on Lake Superior's North Shore. Piles of unsorted rock deposited at the edge of a receding glacier are called ***moraines. Lateral moraines*** form along the side of a glacier. ***Terminal*** (or end) ***moraines*** form at the end of a glacier when it stops growing, pauses, and then retreats. ***Ground moraines*** are unsorted sediment dropped along the general path of the glacier. In central Minnesota, thousands of ***kettle lakes*** (also called ***potholes***) formed as giant chunks of glacial ice rested on the land to melt, formed depressions in the soil, and filled with groundwater. ***Eskers*** are strings of long, low ridges created as melting rivers of water beneath glaciers deposited soil. Hilly ***kames*** formed in one of two ways: from water pooling at the surface of a glacier, or, more dramatically, from a river of meltwater shooting water off the edge of a glacier. In either case, kames formed from soil and rocks being deposited in one spot. Strewn about the prairies and farm fields of southern Minnesota, farmers still find ***glacial erratics,*** which are rocks and boulders of distant origin deposited by glaciers. Geologists have determined that many of these erratics originated north of Minnesota, the same place where glaciers stripped the topsoil down to the bedrock. Good examples of eskers, kames, kettles, erratics, and moraines appear in Glacial Lakes State Park near Alexandria.

First Forests

The first trees to move in as the glaciers retreated, perhaps some 10,000 to 11,000 years ago, were spruce. These trees, offspring of the conifers that had rimmed the fingers of ice at their southernmost reach, thrived well in the still-cold climate. But as the earth warmed even further, seeds from southern deciduous trees began to take root in Minnesota, and the spruce were relegated to the northern part of the state. By 9,000 years ago, the warming and drying trend brought prairies nipping on the heels of the deciduous trees as fires prevented trees from encroaching on the grasslands to the west.

Forest Change

The prairie brought in by postglacial warmth covered much of the southern half of the state for thousands of years. Then, about 5,000 to 6,000 years ago, rapid change began once again. The climate cooled and soil moisture increased. This decreased the frequency and severity of fire, and enabled new trees to move in from the east and become established forests.

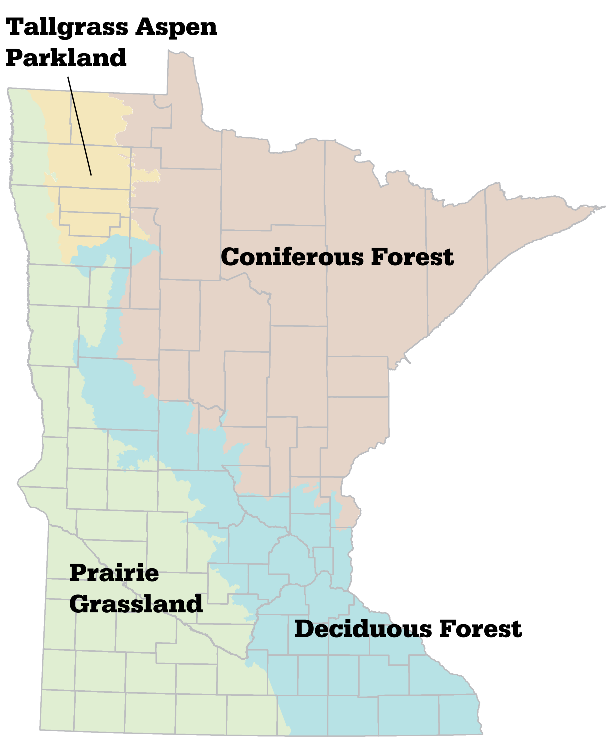
About 1,000 years ago, the forests of what is now Minnesota looked much the same as they did before the 1800s—when Europeans first set eye upon them. Because of the cycle of warming and cooling that followed the retreat of the last glaciers, trees eventually graced more than half of the state. Before European settlement, some 31.5 million acres (about 61 percent) of the 51 million acres that constitute Minnesota's land base was forested.

Biomes

This was far from a single, massive forest, however. Across the state, differing conditions stimulated the growth of different types of forest communities, called biomes. A ***biome*** is a regional ecosystem characterized by the plant, animal, and microbial communities that have developed under specific soil and climate conditions. Minnesota is home to four biomes: coniferous forest, deciduous forest, prairie grassland, and tallgrass aspen parkland. The Minnesota Department of Natural Resources (DNR) and U.S. Forest Service have developed a detailed ecological classification system for Minnesota that outlines the parts of each of Minnesota's four biomes. (The ecological classification system refers to biomes as ***provinces.***)

Coniferous Forest Biome

In the northeast, where glaciers recently ended their poleward retreat, they left behind thin soils blanketing bedrock. Climate was harsher, too, with north winds bringing temperatures plunging far below zero during long, dark winters. These cool but moist conditions favored the growth of conifers, which can thrive on poorer soils because, unlike deciduous trees, they don't need to stockpile nutrients to grow new leaves each spring. Conditions also favored trees such as paper birch, quaking aspen, and balsam poplar that have special adaptations for surviving super-cold temperatures (see Chapter 1). As a result, much of the land north of what is now Pine City and east of the Mississippi became the home mainly of coniferous forests—pine, spruce, fir, and tamarack, often mingled with aspen and birch.



For biome comparison, see table on next page.

Tallgrass Aspen Parkland Biome

Although this biome seems quite small on the map of Minnesota, it is actually part of a much larger biome that extends north through parts of the Canadian provinces of Manitoba, Saskatchewan, and Alberta. In Minnesota, this biome is a natural transition zone sandwiched between the windy prairies to the west and the wetter coniferous forests to the east. Characterized by low moisture, high winds, and cold winters, much of this landscape still depends on frequent fires. Consequently, plants and animals here have to be tough, such as aspen, bur oaks, bluejoint grass, yarrow, arctic shrews, and snowshoe hares. Because much of the area consists of level and poorly drained lake plains of now-extinct glacial Lake Agassiz, today much of this biome is farmed.

Deciduous Forest Biome

The deciduous forest is marked by a band stretching diagonally through the state from northwest to southeast and thickening in what is now the Twin Cities area. The band excludes the tallgrass aspen parkland in the north. The deciduous forest thins along the Minnesota River to the west and thickens around the Mississippi River south to the Iowa border. Within this band, there is a strong contrast between winter and summer. In winter, cold air masses descend from the Arctic and in summer, warm, moist air masses rise from the Gulf of Mexico. In this environment, deciduous trees such as elms, maples, hornbeams, ashes, and oaks, thrive. Where fires were common, scattered oaks interspersed with grasses and forbs, once dominated much of south-central Minnesota. Each fall, the forest floor is blanketed with trillions of leaves, shed by deciduous trees to prepare for winter. As leaves, branches, and logs decay, they add nutrients to the soil. The famous Big Woods also grew in the deciduous forest. Formed on moraines, and protected from fires in the western prairies by many lakes and rivers, the Big Woods covered more than 3,000 square miles of the south-central part of the state. The trees that characterized it—sugar maple, basswood, oak, elm, and the like—thrived on the calcium-rich soils. In places, the Big Woods grew so dense that sunlight could not even reach the forest floor. Remnants of this huge forest can still be seen in Nerstrand Big Woods State Park, near Faribault.

Wildflower enthusiasts favor the Big Woods for its yearly display of spring ephemerals, the wildflowers that bloom early, quickly, and all at once as soon as the sun melts the snow and before the forest canopy shades out sunlight.

A landscape of trees scattered or spaced across a grassland (periodically grazed or burned) is called a savanna.

Prairie Grassland Biome

Where are all the trees? Not in western Minnesota! Here, rolling hills, high winds, and grasses dominate. Even though this area is characterized by rich, deep soils, this was the domain of tallgrass prairie, stretching east from Illinois, across Iowa and up through the western portion of Minnesota. Fire was a frequent check on woody vegetation, and trees persisted mostly in fire-tolerant oak ***savannas,*** in protected valleys (cottonwoods, elms, ashes, and willows), or not at all. Today, less than 1 percent of the original 18-million-square-mile landscape exists, and the tallgrass prairie is considered functionally extinct as an ecosystem. Recent travelers through this area note acres of farms, mostly corn and soybeans. Yesterday and today, trees grow along rivers and streams. Today, trees also grow as planted windbreaks around farmsteads and along fencerows to prevent soil erosion from the ever-blowing winds.

A Comparison of the Climatic Elements in Minnesota's Four Biomes

Biome	Average Annual Precipitation	Average Annual Temperature	Plant Examples	Animal Examples	Average Growing Season Length (days)
Coniferous Forest	21"– 32"	36°– 41°F	Black spruce, Northern white cedar, Balsam fir, Red pine, Fly honeysuckle	Wood frog, Boreal chickadee, Compton's tortoise, Shell butterfly, Gray wolf, Moose	90–100
Tallgrass Aspen Parkland	20"– 22"	35° – 44° F	Aspen, Heart-leaved willow, Wiregrass sedge, Small white lady's slipper, Little bluestem	Sharp-tailed grouse, Sandhill crane, American bittern, Canadian toad, American elk	90–130
Deciduous Forest	24"– 35"	39° – 45° F	Northern red oak, American basswood, Sugar maple, Prickly gooseberry, Rue anemone	Eastern hognose snake, Cerulean warbler, Eastern pipistrelle bat, Gray fox, Eastern spotted skunk	100–130
Prairie Grassland	18"– 33"	37° – 45° F	Big bluestem, Blazing star, Purple prairie clover, Prairie dropseed, Leadplant	Great plains toad, Greater prairie chicken, Upland sandpiper, Pocket gopher, Badger	130–180

Early Humans

Even while Minnesota's forests were still saplings taking tenuous root on the newly laid glacial soils, human footsteps were treading pathways through them.

The few clues we have to the lives of the people who first lived here after the glaciers suggest that they were big-game hunters. The trees that grew upon the land likely played a role both in providing habitat for their prey and for supplying raw materials for tools, weapons, and other necessities of life. As the forests changed with the shifting climate, so did the people and their interaction with forests. When deciduous forests began to follow the first conifers, people learned to use the berries and nuts they yielded as food, along with the small mammals that thrived beneath their boughs. Durable stone points and evidence of campsites in McCarthy Beach State Park near Hibbing dating back to 10,000 years ago lead archaeologists to think that traveling bands of hunters followed woodland caribou and now-extinct species of bison and woolly mammoth.

Dakota and Ojibwe

The Woodland Period began about 1,000 years ago. A people called the Dakota had arrived on the scene. The Dakota cultivated plants rather than depending solely on hunting and gathering for food. This undoubtedly added a new perspective to the early inhabitants' relationship with the forest. However, it is clear from archaeological records that the forest continued to be a valuable source of food and raw materials for housing and other necessities of life.

In the 16th century, when the first European explorers arrived in the eastern United States, the Dakota were still the main inhabitants of the land we now call Minnesota. However, their claim on this land was soon challenged by the Ojibwe, or Anishinabe. The Ojibwe moved in from the northeast, pushing into new territory in response to pressure from European colonization.

By the mid-1700s, the Dakota and Ojibwe were fighting over rights to the limited resources of the land. By 1800, the Ojibwe had largely taken over northern Minnesota, and the Dakota had moved southwest to the prairies.

Both for the Dakota and for the Ojibwe who moved in later, the forest was a home as well as a resource. It was treated with respect and the recognition that harming forests would harm their own lives.

The forest provided its human inhabitants with the necessities of life. It gave them shelter in the form of a natural break from the wind and rain, and yielded building materials for tepees, lodges, and other housing. It was a source of an endless array of foods, from meat and berries to maple sugar. It provided dishes from birch bark and wood, transportation in the form of birchbark and dugout canoes, travois poles, sleds, and snowshoes. It was a source of

Fire

Strong and staid though they were, Minnesota's early forests were not stagnant. One of the major forces of change they faced was fire. Fires of varying intensities would periodically sweep through the trees. Rather than being agents of destruction, low-intensity fires actually benefited plant and animal communities and soil. They released nutrients trapped in the soil, enriching the environment for new plants moving in. For some trees such as the jack pine, fire aided reproduction. For sun-loving trees such as birch or oak that are unable to grow up in the shade of an established forest, fires cleared the way for new growth.

European explorers arriving at wooded areas of the United States before the 19th century often described forests as "open" and "park-like" and marveled at how easily one could travel and hunt. Later in the 19th century, writers described forest as "dense" and "dark." Historians and scholars who study charcoal deposits, pollen counts, and eyewitness accounts from explorers and settlers, believe that American Indians extensively used fire to manage their land to improve wildlife habitat and hunting, improve visibility, encourage desirable plants such as raspberries or blackberries, clear land for farming, and prevent large, hot, damaging fires. When Indian populations decreased, regular burning also decreased.

beauty, and provided a foundation for stories and a deep awareness of the interconnectedness of all things that is a unifying theme in much of American Indian life. The attitude of American Indians toward this resource is illustrated by the Dakota word for things of nature: mi-ta-ku-ya-pi, or "my relatives."

Even with their tremendous respect for the forest, American Indians knew that the resource could be modified for human purposes without destroying it. Some periodically set fires to create open areas, which then drew game for hunting. Stands of maple trees sometimes were managed to maximize sap production. Despite these modifications, however, the primary relationship of these first human inhabitants of Minnesota's forests with their environment was one of living in cooperation with, and not just off of, the land.

European Explorers

The first European explorers to set foot in what is now Minnesota in the 1600s were in awe of the vast expanses of forest they found here. They quickly became aware of the latent economic value of the forest—not so much in the form of the trees themselves, but in the form of pelts of beaver, fox, and other animals that made their homes in the forest. A thriving fur trade soon sprang up, with its roots reaching deep into the forests along lakes and rivers that formed the highways of the voyageurs—men employed by fur companies to transport pelts to and from remote areas. But the forests themselves remained relatively undisturbed.

To sum up

Chapter Three: Forests Before Settlement (Pre-1800s)

- Glaciers covered most of Minnesota before they retreated 10,000 years ago.
- Minnesota has four biomes formed by varying conditions in the state: coniferous forest biome, deciduous forest biome, prairie grassland biome, and tallgrass aspen parkland biome.
- Early people used the forest and its products to sustain their lives.
- Early people managed the forest through setting small, intentional fires.
- The first Europeans to arrive in Minnesota came for the wealth of furs from animals that lived in the forest.

Minnesota Historical Society—Artist: Frances Ann Hopkins. Used with permission.

Scene of early voyageurs called *Canoes in a Fog, Lake Superior.*

How an active sentiment can be awakened for preservation of Minnesota timber I don't know, as the present sentiment is to 'grab all you can' and no one cares about the future."

—George Goodrich, fire warden,

Becker, Minnesota, January 13, 1896

CHAPTER FOUR CHANGES IN THE FOREST (1800s–PRESENT)

Clearing the Land

In the early 1800s, dramatic change began to arrive from the east. The French, and later the British, fur traders plied their trade in the northern expanses of the state. At the same time, other Europeans were gradually pushing their way westward across the growing nation in search of the farmland riches they had been told were part of this vast, unknown terrain. By the 1840s, settlers had begun establishing farms on lands that the Ojibwe and Dakota had given up through treaties in the southern part of what is now Minnesota.

As these new settlers trickled in, they were quick to spot opportunity. And with their minds set on farming, the soil was it! In the forests of the southeastern and central parts of the state, they saw rich cropland just waiting to be freed from the weight of the enormous deciduous trees towering above them. Not only that, but they needed wood to build their houses, barns, mills, and towns.

The task was clear, and they set to it with the radical resolve that gave many immigrants the strength to stand up against the hardships that drove them across the ocean in the first place. The trickle of pioneer farmers soon became a steady stream, and most of the rich deciduous forest in the southern and central part of what is now Minnesota fell to the ax and to fires deliberately set to clear the land for farming.

The Logging Era

As America stretched its boundaries across the continent, the demand for building supplies soared. Forests became, in the eyes of some visionaries, collections of ***timber*** just waiting to become joists, rafters, tables, chairs, drive tongues for covered wagons, and paper stock for leaflets and newspapers announcing the riches of the West. And the very best timber, it seemed, waited in the great, but difficult-to-access, white pine forests of northern Minnesota.

Many view the construction of Minnesota's first sawmill at St. Anthony Falls in 1821 as the start of the logging industry in the state. In 1837, treaties with the American Indians opened up much of Minnesota to logging. With that change, and with the increasing demand for wood caused by the settling of the prairies to the south, timber companies pushed into the northern pine forests. The first commercial cuts were made along waterways that could provide transportation for logs. Trees were cut in the winter and hauled by horse

Minnesota Historical Society—Photographer: Benjamin Franklin Upton. Used with permission.

Old government sawmill and flour mill in Minneapolis, circa 1857.

or oxen to the edge of streams. Then, when spring came, they were floated downstream in rivers to mills.

From the time the first lumber was cut at Marine on St. Croix in 1839 to the last big log milled in the Virginia Rainy Lake Mill in Virginia in 1929, lumbering in Minnesota was big business. Timber barons amassed great wealth harvesting the vast stands of white and red pines. Minneapolis, Stillwater, and other towns along the St. Croix and Mississippi rivers became hubs of logging-related activity. By the 1930s, the major lumber companies operating in Minnesota's north woods included General Logging, a Weyerhaeuser enterprise; International Lumber,

Minnesota DNR

Because the logs cut by the various timber companies were all mixed together, logs transported to market by river were branded like cattle by their owners so they could be sorted out at the mill.

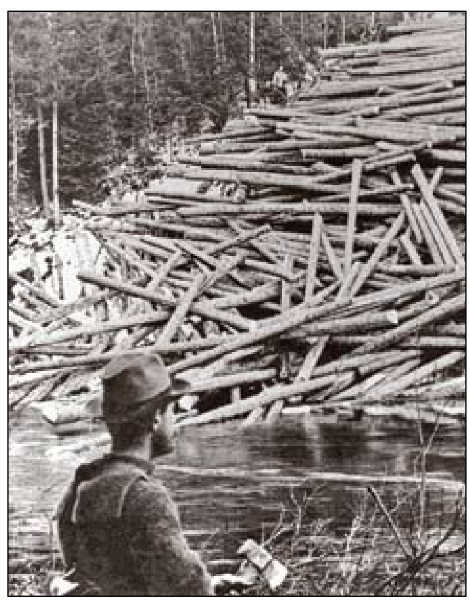
later International Paper; North Star, a division of Kimberly-Clark; and the Minnesota and Ontario Paper Company, the largest corporation in the state.

During the heyday of logging, 1890 to about 1930, tens of thousands of lumberjacks—men who felled huge trees with muscle, ax, and saw rather than by steam engine—toiled in the woods during frigid winters. Lumberjacks earned their livelihoods cutting trees, removing tree limbs, and moving logs on sleighs powered by teams of horse or oxen, from the woods to landings at the river's edge. Thousands more worked on the river drives, moving the logs to hungry sawmills downstream. Though floating on rivers was usually efficient, sometimes logs would jam up and the river drivers would need to risk their lives using dynamite and muscle power to break the jam. In the meantime, 20,000 men worked from dawn to dusk cutting what some saw as endless white pine.

Timber is often measured in a unit called a board foot—the amount of wood in a board that is 1 inch thick, 12 inches long, and 12 inches wide or 144 cubic inches. A ***board foot*** is a volume measurement that foresters use to describe how much timber exists in a forest or at a pulp mill.

The average pay for these workers was a dollar per day plus room and board. (For comparison, in 1890, one dollar could buy 10 pounds of flour, 2 pounds of round steak, 2 quarts of milk, and 20 pounds of potatoes.) Consequently, hundreds of Minnesota towns depended on logging for their economic existence. Immigrants, eager to start a new life in America, found themselves working the winter camps where labor was in short supply.

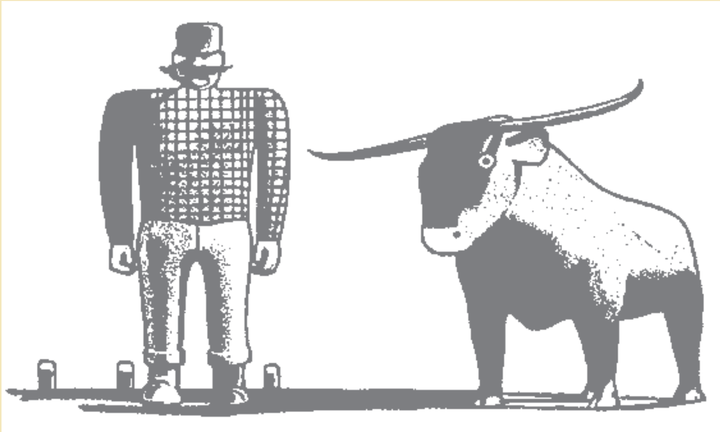
Winter logging was a constant battle against the elements. Frozen ground was necessary to move the heavy logs with horses and oxen. Ice roads for sliding logs had to be built and maintained. Heavy snow, early thaws, and low spring water levels could jeopardize a winter's work. These extreme conditions, combined with the rugged individualism of the woodsmen, gave rise to some rich lumberjack folklore. It was from these stories of great feats of strength, endurance, and ingenuity retold around the bunkhouse workstoves, that the legends of Paul Bunyan and his mighty Babe the Blue Ox grew.



Hinkley Fire Museum. Used with permission.

Breaking up log jams on Minnesota rivers was dangerous work involving dynamite and muscle power.

Paul Bunyan



The tall tales of Paul Bunyan and his blue ox, Babe, are legendary. Like the one about the day Babe was stung by a Bunyan-sized bee and bolted for the West Coast. Paul grabbed Babe's tail, dug his heels in, and stopped the ox. Thousands of people still visit the trench left by Paul's boots. It is known today as the Grand Canyon.

Thousands of storytellers, gathered around the stove in the bunkhouse of logging camps in Minnesota's northern woods, have contributed their chapter to the classical picture of Paul Bunyan. Those storytellers gave Paul the blue ox, Babe, who measured 42 ax handles and a plug of chewing tobacco between the horns. They helped to create the lumberjacks of Olympian feats; strong, brave jacks who lived in a country of giant bears and mosquitoes the size of hummingbirds.

Paul and Babe are perhaps the most renowned of lumberjack legends. However, many "legends" were, in fact, based on truth. While there is some skepticism about the lumberjacks' unearthly abilities during the logging era of the early 1900s, there is no question that these woodsmen led a harsh, if not unique and colorful, life while earning their livelihoods. To be considered good lumberjacks, men had to be energetic, strong, and able to work in the cold for long hours at a time.

In 1857 alone, some 100 million board feet of lumber were cut in the state. By 1889, with the rapidly growing railroads both increasing demand for wood and providing a new means to get wood from the forest to the market, production topped 1 billion board feet. The introduction of new technologies that made harvesting, transporting, and processing logs easier and more efficient helped that number double within the next decade to its all-time peak of more than 2 billion board feet in 1899. (All numbers are annual.)

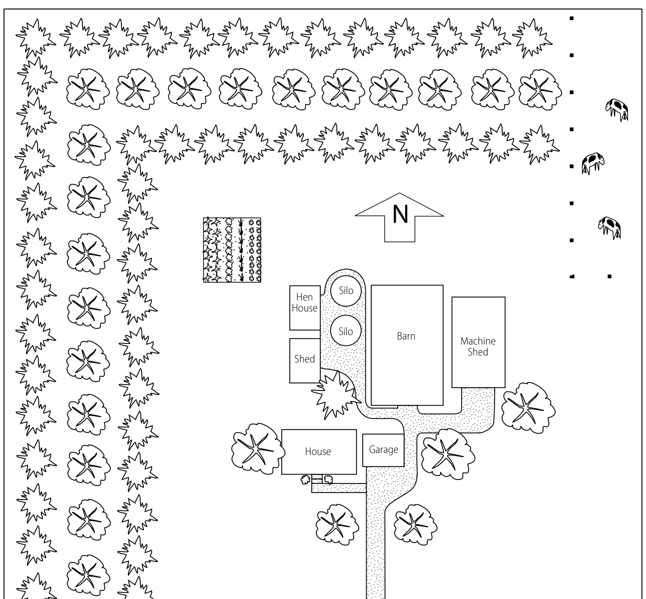
The cut-and-run logging characterized by this era left behind piles of tinder-dry brush and stumps called ***slash.*** Loggers believed that farmers would want to move into the lands they were clearing, so they didn't even consider planting new trees. Fires were periodically set to rid the land of these leftovers, and not all fires respected the boundaries intended by those who set them. For roughly 30 years, from 1890 through 1920, forest fires peppered the newspapers with stories of their ravages: 418 dead in the great Hinckley Fire of 1894; mass destruction in Chisholm in 1908; great damage in Baudette and Spooner in 1910; and 453 dead in the Cloquet–Moose Lake Fire of 1918. (Read about some famous Minnesota forest fires on page 28.)

By the mid 1920s the most difficult to reach timber in northeastern Minnesota was being cut and by 1930, loggers were beginning to discover that they had literally worked themselves out of their jobs. Only a remnant of the massive pine forest that once graced Minnesota remained. With the aid of the frontier-piercing railroads, many of the lumberjacks who had changed the face of Minnesota forever headed out to the Pacific Northwest to ply their trade there.

Windbreaks and Shelterbelts

Although some of the early settlers of Minnesota's agricultural land saw trees as obstacles, others recognized that trees could be their allies by helping to protect their families, animals, and soil from wind and weather.

The value of trees as windbreaks and shelterbelts was driven home during the dry and windblown Dust Bowl years of the 1930s. Farmers began to plant trees in rows to slow the winds that cut across plowed fields, stealing valuable topsoil and leaving behind barren land. The field-lining ***windbreaks*** not only helped keep topsoil from being blown away, they also retained moisture by keeping snow on the farm field, added beauty and variety to the landscape, and provided homes and travel corridors for wildlife. ***Shelterbelts***—L-shaped lines of trees—wrapped around the windward side of homes and farm buildings, provided many of the same functions, and reduced fuel and animal feed needs by creating a pocket of warm air around houses and outbuildings.



Ideal shelterbelt planting for a farmstead. Small, 15-foot trees line the outer perimeter, flanked by 70-foot tall trees through the middle, with rows of 15- to 20-foot trees lining the shelterbelt closest to the buildings.

Arbor Day

Arbor Day is a time to celebrate trees. Historically, it is a time when people plant trees and shelterbelts, and rally to green up their communities. In the 1870s, most states, including Minnesota, established Arbor Day. Today, all states have an Arbor Day, mostly on the last Friday in April. In 1978, Minnesota became the only state to celebrate an entire month—May—as Arbor Month.

Roots of Conservation

Even in the heyday of logging, the roots of conservation—of treating the forest as a resource to be maintained rather merely extracted for its timber—were being laid in Minnesota. Although the white pine forests of the north seemed endless to some, settlers in the prairie lands of the southwestern part of the state, who lacked wood for fuel and homes and standing trees for shelter, felt the price of being treeless.

Recognizing the need for trees in the vast open spaces that were being carved up into farms, the Minnesota Legislature in 1873 passed a law giving farmers $2 a year (with a 10-year limit) for every acre of saplings they cared for. That same year, the federal government passed the Timber Culture Act. This law supplemented the Homestead Act, which gave 160 acres of land to anyone willing to farm it for five years, by requiring settlers to grow trees on at least 40 of those acres. Within a year, the acreage required by law was reduced to 10, but the message remained: Trees are important. Consequently, some 8 million trees were planted in 1873, totaling more than 25,000 acres within the next seven years.

The Minnesota State Forestry Association, established in 1876, is Minnesota's first forest conservation organization. Today it is known as the Minnesota Forestry Association.

The disastrous Hinckley Fire of 1894 indirectly stimulated conservation by moving the Minnesota Legislature to create a state fire warden position. The first chief fire warden, former Civil War general Christopher Columbus Andrews, had spent several years in Scandinavia studying reforestation techniques and was anxious to apply them here. The first state forest was established in 1900 when Governor John Pillsbury donated 1,000 acres of cutover pine lands in Cass County to the state, and the land was designated Pillsbury State Forest. In 1903, the state established a school of forestry at the University of Minnesota—the second of its kind in the nation—to train professionals, and set up a state-run nursery, state forest park preserves, and more state parks that emphasized natural resource conservation.

Minnesota Forestry Timeline	
1821	Minnesota's first sawmill opens at St. Anthony Falls to cut timber for the construction of Fort Snelling.
1837	Treaties with American Indians open most of Minnesota for logging.
1839	Lumber is cut at Minnesota's first commercial sawmill built at Marine on St. Croix to process logs floated down the St. Croix River.
1857	100 million board feet produced in Minnesota.
1858	Minnesota gains statehood.
1873	Timber Culture Act augments the Homestead Act by giving title of an additional 160 acres of land to any person who plants trees on at least 40 acres of it.
1876	Minnesota State Forestry Association is founded to promote wise stewardship of forest lands.
1890	The heyday of logging in Minnesota begins (ends in 1930).
1894	The Hinckley fire kills 418 people. This fire was so destructive because it burned slash piles—remnants of logging operations—that left over 350,000 acres of unstoppable fuel.
1895	The Minnesota Legislature appoints the state auditor as forest commissioner. The auditor appoints General C.C. Andrews as Minnesota's first chief fire warden.
1899	Logging hits an all-time peak, with 2 billion board feet of lumber produced in Minnesota in just one year. The Minnesota State Forestry Board is created.
1900	The Pillsbury State Forest is established when flour mill owner John Pillsbury donates 1,000 acres of cutover pine land to the state.
1903	The School of Forestry at the University of Minnesota is established.
1908	The Minnesota National Forest is established (its name changes to Chippewa National Forest in 1928).
1908	The Chisholm fire burns 20,000 acres.
1909	The Superior National Forest is established.
1910	The Baudette–Spooner fire kills 42 people.
1911	The Minnesota Legislature creates the Minnesota Forest Service.
1918	The Cloquet–Moose Lake fire kills more than 450 people.
1925	The Minnesota Department of Conservation is established. (In 1971, the name changes to the Minnesota Department of Natural Resources).
1929	The Virginia Rainy Lake Mill in Virginia cuts its last big log, signaling the end of the heyday of logging in Minnesota.
1933-1943	Numerous reforestation activities take place under the Civilian Conservation Corps and the Works Progress Administration (renamed in 1939 to Work Projects Administration).
1930-1937	Dust Bowl era causes massive droughts and fires in Minnesota and throughout middle America.
1953	Red pine *(Pinus resinosa)* is named Minnesota's "state tree."

The federal government created two national forests in Minnesota: the Minnesota (1908) and the Superior (1909). (In 1928 the Minnesota was renamed the Chippewa National Forest.) Leaders began to acknowledge that some land just naturally was better for trees than for crops, and in 1914, the state's constitution was amended to allow the Legislature to create state forests out of such land.

Minnesota Historical Society

Crews from the Works Progress Administration control a fire in northern Minnesota.

The economically trying times of the 1930s ironically became a time of hope for Minnesota's forests. Many of those who had tried to set up farming in the cutover lands of the north around the turn of the century had found themselves unable to scratch out a living on the unsuitable acreage. By 1930, these owners had turned their land over to the government in lieu of taxes. In 1932, a governor's commission recommended that these lands be reforested for income and recreation. And, thanks to the Depression, the workforce was available to carry through. Many of the forests that grace the state today are partly the product of laborers hired by the Works Progress Administration (WPA) and the Civilian Conservation Corps (CCC).

U.S. Forest Service

The story of Smokey Bear emerged from a lightning-caused fire in New Mexico in 1950. A firefighter found a black bear cub clinging to a tree after a fire. The cub was cared for and then employed by the U.S. Forest Service to spread the message, "Only You Can Prevent Forest Fires."

Gradually, the concept of forest management evolved into a full-fledged discipline. Recognizing that forests can be renewable resources—but only if they are treated as such—people began to use trees as though the future mattered. Landowners—especially big ones, such as the federal and state governments and timber and paper companies—began hiring professional foresters to help them manage forests. Planning for the next growth of trees became an assumed part of the logging process. Forestry research began to provide concrete advice on how management techniques such as planning, planting, inventorying, harvesting, fire management, and thinning could work together to ensure the ongoing health of the forest. People began to realize that the best forests are not necessarily those untouched by human hands—that good management can improve wildlife habitat, environmental protection, and aesthetics as well as better trees.

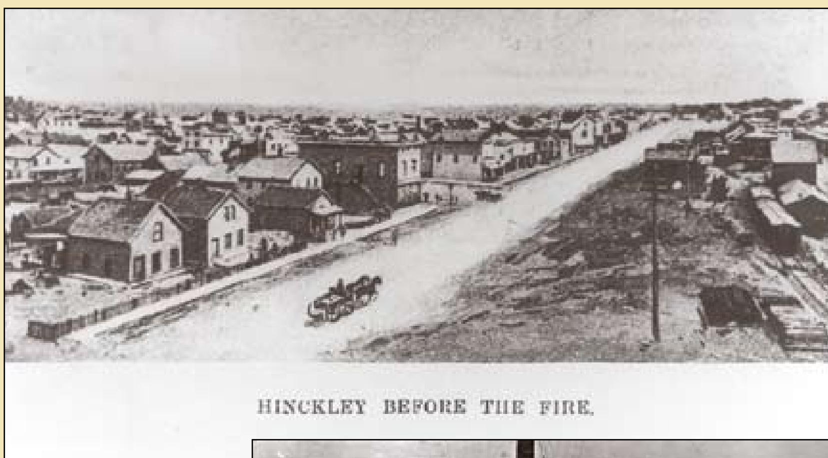
In 2001, Smokey Bear's motto became "Only You Can Prevent Wildfires." The motto was changed from "forest fires" to "wildfires" because the U.S. Forest Service occasionally manages forests and grasslands with fire. Unintended, human-caused *wildfires* do the most damage.

Hinckley Fire

Sometimes fuel accumulates and catastrophic fires erupt. At the turn of the 19th century, the timber industry was moving fast over Minnesota forests. Loggers removed millions of mature trees and shipped them away to growing metropolitan areas. The Hinckley fire, the first of the four "famous fires" of Minnesota, was no simple forest fire. Stark statistics tell the story: 320,000 acres (500 square miles) burned, more than 400 lives lost. For thousands of years, fires of varying intensities had periodically burned through the forest. However, in the 19th century, timber-harvesting activities helped to increase the amount of fuel on the ground. Logging operations took only the largest trees, leaving piles of fuel waiting for the right conditions for a devastating fire. Those conditions came in the early years of the 20th century. Near-drought conditions made these fuels tinder-dry. At the same time, agricultural settlements increased the number of homes and families living in these cutover lands, thus expanding the potential for tragic results.

The city of Hinckley owed its existence to its strategic location in the center of the white pine timber region. The Brennan Lumber Company, the major employer in Hinckley, hired roughly 400 workers. The Brennan complex consisted of a sawmill, planing mill, lumberyard, and a stable of 90 horses. At the time of the fire, its wood yard was stocked with 28 million board feet (enough wood to make a 1" by 12" board reach from New York City to Los Angeles, California, and back to Buffalo, New York) of lumber awaiting shipment and another 8 million board feet (enough to make the same board reach from Minneapolis to Orlando, Florida) of logs ready to saw.

It was in this situation that on Saturday, September 1, 1894, sparks from burning stumps at the Brennan yard blew into the lumber pile. The fire quickly grew out of hand and spread toward the town. Firefighters and mill hands tried to keep ahead of the flames, but Fire Chief Craig assessed the futility and ordered the men to abandon equipment and evacuate the town. Although the fire burned several communities and spread over parts of five counties, it became known as the Hinckley fire because that city sustained the greatest loss in lives and property.



Hinckly Fire Museum. Used with permission.

Hinkley after the fire.

Famous Minnesota Fires				
Area	**Date**	**Number of acres burned**	**Number of lives lost**	**Cause**
Hinckley Forest Fire*	September 1, 1894	350,000	418 (may be higher since American Indians weren't counted)	Sparks from burning stumps igniting a 28-million-board-foot pile of lumber at the Brennan Lumber Company.
Chisholm Forest Fire*	September 4, 1908	20,000	0	Windy conditions brought sparks into piles of slash (woody debris left over after logging) within village limits.
Baudette–Spooner Forest Fire*	October 9, 1910	1,000,000	42	Windy conditions fanned several small fires into a large one that consumed the towns of Baudette and Spooner. The death toll would have been much higher, had not trains been available to whisk to Canada hundreds more just ahead of rampaging fires.
Cloquet–Moose Lake Forest Fire*	October 12, 1918	1,200,000	453	Six distinct fires burned together, fanned by wind; 5,200 people injured or displaced; 38 communities destroyed.
Fires of 1931 (Dust Bowl)	1931	993,000	4	There were several, but the largest was the Red Lake Fire, which ran from Red Lake to the Canadian border.
Huntersville Forest Fire (Wadena, Hubbard, Cass counties)	September 7, 1976	23,000	0	A spark from a farmer's haymaking machine ignited dry grasses.
Carlos Edge Fire	October 19, 2000	8,500 acres	0	Caused by escaping sparks from a home debris pile.
Ham Lake Fire	May 5, 2007	75,851 (36,443 in Minnesota; 39,408 in Canada)	0	A campfire-started blaze consumes some of the forest affected by the wind-storm of July 4, 1999, in the Boundary Waters Canoe Area Wilderness. A little more than half of the acres burned were in Canada.

* The "Famous Four" fires of early Minnesota history

To sum up

Chapter Four: Changes in the Forest (1800s–present)

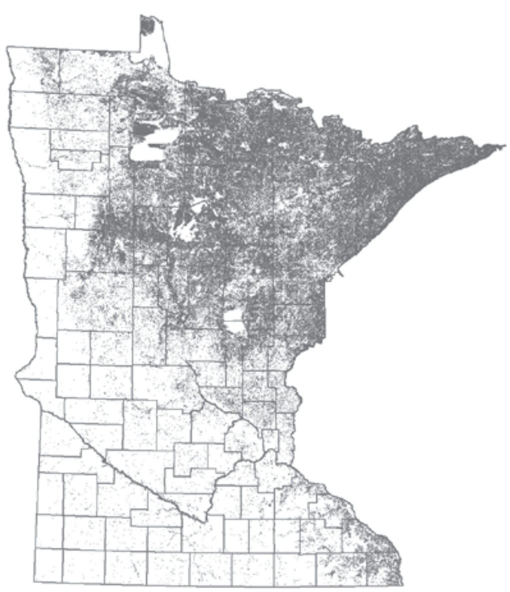
- Early settlers cleared forests for farming.
- Logging became one of Minnesota's primary industries, especially from 1890 through 1930.
- Over-harvesting and unmanaged cutover lands made many areas susceptible to massive wildfires.
- Several wildfires occurring around the turn of the century burned millions of acres and took hundreds of lives.
- Forest conservation practices include planting windbreaks and shelterbelts, establishing policies and practices that encourage people to replant and care for trees, establishing a state fire warden position, and dedicating public forests.

"In the emerging global economy, nations should be increasing, not decreasing, their dependency on wood fiber because wood is renewable, recyclable, biodegradable, and far more energy efficient in its manufacture and use than are products made from steel, aluminum, plastic, or concrete. Furthermore, growing forests and the lumber they provide store large amounts of carbon dioxide that would otherwise escape into the atmosphere, adding to the potential for global warming."
—Dr. James Bowyer, University of Minnesota

CHAPTER FIVE FORESTS TODAY

The trees and forests Minnesota travelers see today are a far different sight from that which greeted the earliest pioneers.

For one thing, there are fewer of them. Largely due to the clearing of the deciduous and southern coniferous forests for agriculture, total forested land in the state has dropped from the pre-European figure of more than 31 million acres to 16.3 million acres (about one-third of Minnesota's land area). Harvest is prohibited on about 1.1 million acres. Although much of this set-aside land is within the Boundary Waters Canoe Area Wilderness (960,000 acres), it includes areas in state and national parks and forests, scientific and natural areas, and corridors and setbacks. Total ***timberland*** (harvestable land)—forest that is considered useful for growing and harvesting trees—is about 15 million acres. More than half (54 percent) of this land is publicly owned.



Current forested land in Minnesota.

In the southeastern third of the state, farming dominates. Trees and forests found there are largely remnants of the extensive mixed deciduous stands that originally grew along the fringe of the prairie, windbreaks or shelterbelts around farmsteads, or urban trees gracing city streets and parks. However, thick deciduous forests still blanket much of the blufflands along the Mississippi River valley. In the northeastern third of the state, quick-growing aspen, birch, and red and jack pine that grew up after the great pine forests were logged, now dominate. Although shade-tolerant spruce and fir have invaded some of these forests, today more than a third (6.96 million acres) of Minnesota's forested acres are primarily aspen. Minnesota has more aspen than any other species of trees.

Forest management today is increasingly focused on stewardship, multiple benefits, and sustainability. Those who care for Minnesota's forests recognize that: 1) this resource is to be used, but not abused; 2) human needs are to be balanced with other goals; and 3) current demands must be compatible with our responsibility to future generations.

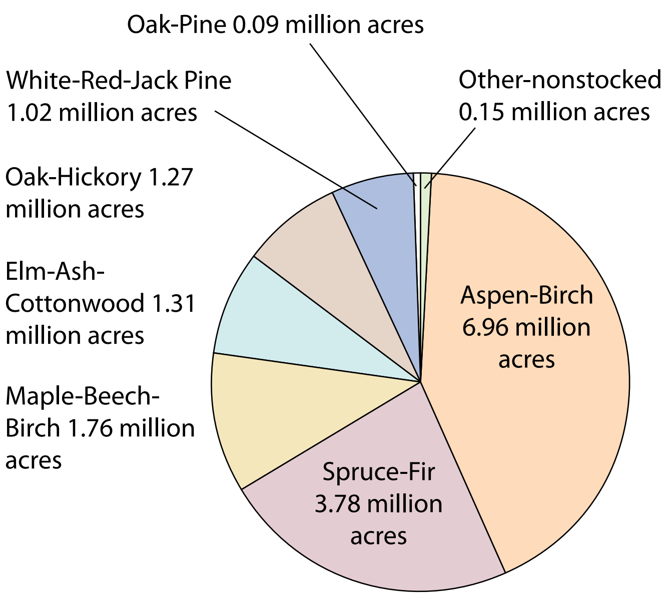
What do Minnesota's forests look like now?

As forests continue to succeed from the logging days of old and undergo active management today, they are also subject to future climate change, diseases, invasive species, and changes in human populations. Therefore, we expect certain species of trees to increase or decrease. Today, common Minnesota trees are aspen and other deciduous trees, whereas a hundred or more years ago conifers like pines and spruces were more common.

Some recent examples of ups and downs:

- Paper birch has declined since 1990 because many birches are old and dying, while others have suffered stress from periodic droughts. Since most birches are relatively old, more work is needed to regenerate birch for the future.
- Since 1990, forests of balsam fir have declined dramatically, by 34 percent. This is mainly because of damage from spruce budworm, which naturally occurs every few years.
- Jack pine forests have decreased by nearly 27 percent in recent years. Jack pine naturally reproduces (re-seeds) through fire and is considered old once it reaches 41 to 60 years. As of 2004, more than half of Minnesota's jack pine was more than 40 years old. To encourage future young jack pine, existing stands need to be harvested or burned, and replanted.

Forest type acres on Minnesota forest land



Forest Type: A classification system based on the most common tree species growing on the site. The forest inventory analysis is the U.S. Forest Service's "tree census."

Old Growth

Ambitious timber companies left few tracts of woodland untouched when they cut through Minnesota's forest lands a century ago. While the vast forests of towering pine that once crowned the state are mostly memories, there are still thousands of acres of mature forests today. The same is true for the once broad-ranging deciduous forests in the southern part of the state, which fell to the farmer's ax in the days of the settlers. Today, aspen covers much of the former pinelands and farms and scattered woods cover much of the former deciduous forest.

Old-growth forests have escaped ax, fire, or saw for a century or more, and survive as living reminders of Minnesota's past. These tracts, which total as much as 600,000 acres statewide, are among the oldest pieces of the patchwork quilt that forms the land around us. Their unique structure, with a mix of tree ages, standing dead trees, canopy gaps, and tip-up mounds and pits, makes them particularly valuable from scientific, educational, and ecological standpoints.

How big is your tree?

Trees are measured in both height and diameter. However, depending on tree species and other factors, the biggest tree is not always the oldest!

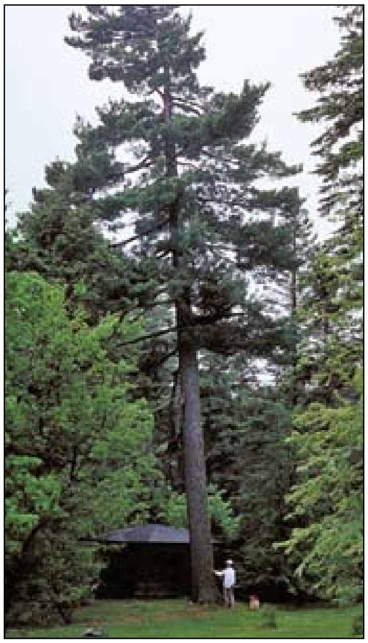
Instructions for measuring trees are in Appendix 4.

Today these forests are the subject of a land-use controversy that epitomizes the challenge of managing a resource with many possible—and not always compatible—uses. Many people view the old-growth forests as natural museums providing historic examples of the sights and sounds that met the very first settlers, as ecological showrooms, as rich and undisturbed habitat for forest wildlife, as a source of seeds for future generations of trees. Others, however, recognize their potential value as a source of timber, and suggest that selective cutting would actually benefit these tracts by keeping them vigorous.

Recognizing that a decision to harvest these areas for timber would permanently alter the forest, the Minnesota DNR has identified and temporarily set aside 38,400 acres of state land to be managed as old-growth forest. This means that the DNR will ensure that people will be able to enjoy and study acres of old-growth forest in the future. Inevitably, these stands must change (due to natural or human forces). But by that time, the DNR will have designated other lands to be set aside as old growth.

Renewing White Pine

In the late 1830s, loggers reached the pine lands of east-central Minnesota. During the next 80 years, most of the choice, large white pines across the state fell to the ax and saw. Agricultural development, urban growth, and extremely hot wildfires that fed on logging slash also took their toll, as did drought, disease, insects, pollutants, and animal browsing. In recent years, many Minnesotans have voiced concern about the loss of white pines.



Minnesota DNR

In response, the Minnesota Department of Natural Resources formed a White Pine Regeneration Strategies Work Group in 1996 to help ensure that white pine once again becomes a healthy component of Minnesota's northern forests. However, while the effects of logging have declined, more people, more deer, and nonnative white pine diseases continue to put pressure on white pine populations. Now, through the efforts of resource management agencies and individuals, white pine is no longer declining, and efforts are underway to allow the white pine to increase even more.

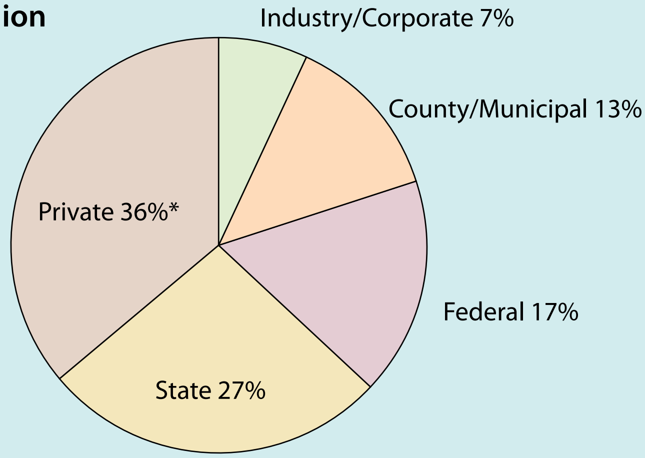
Forest Legacy Program

Congress established the Forest Legacy Program as part of the 1990 Farm Bill. This program protects environmentally important forests throughout the state that otherwise might be converted into something other than forest. Federal and local matching funds buy development rights and conservation easements in these targeted areas. Landowners still own the land and can still use it for timber, recreation, hunting, and hiking as long as they don't conflict with the terms of the easements.

Who Owns the Forests?

Who owns and manages Minnesota's forests today? Most of Minnesota's forest lands belong to you and me. As members of the public, we are responsible for the 57 percent of the 16.3 million acres of Minnesota's forest lands in the hands of state, federal, county, and municipal government agencies. Professional foresters manage these lands for us. Another 36 percent of Minnesota's forest lands is owned by private citizens. Only 7 percent of Minnesota forest lands is owned by industry.

Who owns Minnesota's 16.3 million acres of forest lands?



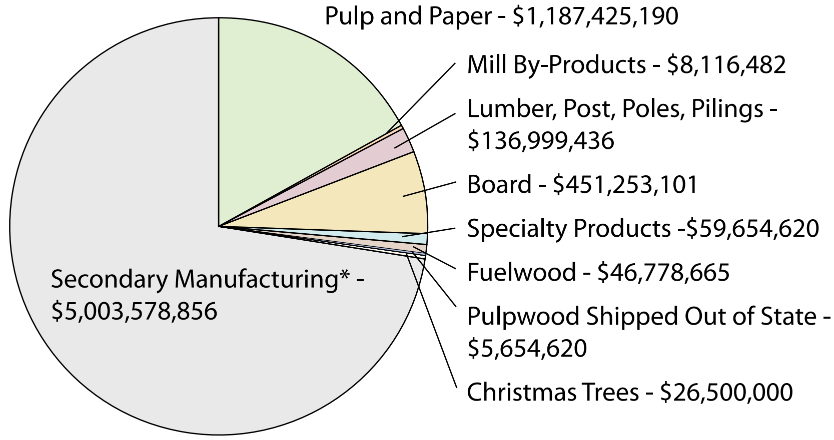
* Includes tribal lands

Source: Minnesota Forest Inventory and Analysis (FIA) 2005 data

Multiple Benefits of Forests

Whereas in the past forests often were managed with a focus on timber production, today's forests are more likely to be managed for long-term sustainability and to provide a variety of benefits: timber, nontimber products, jobs, wildlife habitat, biological diversity, cultural resources, improved water and air quality, carbon sequestration, recreation, aesthetics, and energy from woody biomass.

Value of forest products manufactured in Minnesota



* Secondary manufacturing is products produced after the primary manufacture of wood. For example, logs are first made into boards, then boards are secondarily manufactured into furniture, buildings, fencing, etc.

Source: Minnesota Forest Industries 2005.

Timber

Trees are still harvested for lumber as they were in the past, but other forest products such as paper, ***oriented strand board,*** and veneer are a bigger piece of the picture than they were a century ago, in part because of the changed mix of tree species. Today, more than 40,000 Minnesota workers get at least some of their income from the forest products industry, which produces between $6 billion and $7 billion worth of products each year. That's a lot of paper and lumber!

Nontimber Products

In addition to timber products such as paper and lumber, forests can provide nontimber products, often made from tree parts such as: boughs, bark, cones, nuts, sap, and seeds. In addition to items made from trees, forests also provide berries, mushrooms, florals, botanicals, and other products. Such products are an important source of income for many people.

Some examples of tree species and the products made from them:

Tree Species	Timber Products	Nontimber Products
Aspen	Pulp and paper, oriented strand board, paneling	Walking sticks
Balsam fir	Pulp for paper, Christmas trees	Seasonal wreaths
Birches	Furniture	Aromatic oil, medicinals, bark products, canoes
Maples	Lumber, veneer, flooring, furniture	Syrup, charcoal, candy, baskets
Oaks	Furniture, cabinets, railroad ties	Firewood
Pine, red	Telephone poles, construction lumber, cabin logs	Pet bedding, decorative and Christmas swags, mulch, firestarters, wreaths
Pine, white	Lumber, doors, furniture, knotty paneling	Pet bedding, decorative and Christmas swags, mulch, firestarters, wreaths
Spruce, black Spruce, white	Pulp for paper	Aromatic oils, florals, sound boards for music instruments, wood, potpourri, gum, wreaths, spruce tops

Jobs
Many jobs depend on trees: forestry, logging, wood products manufacturing, pulp and paper products, furniture, printing, and more. In Minnesota, forestry creates more than 40,000 jobs and brings between \$6 billion and \$7 billion to the economy each year. The forest products industry is the fourth largest in the state! Most of the logging, pulp, and paper operations are in the north, and most printing and publishing operations are in the Twin Cities. *Source: Minnesota Forest Industries, 2005 data.*

Wildlife Habitat
Forests provide diverse food and habitat for a variety of mammals, birds, insects, reptiles, amphibians, microorganisms, and fish. This includes game species such as deer, ruffed grouse, and trout, as well as nongame species such as scarlet tanagers, Blanding's turtles, and bobcat. Large, shady trees help keep trout streams cool. They also provide acorns for squirrels and bears, fallen logs for toads and snakes, and nutrients for a multitude of insects and microorganisms, the food base for the insect-eating animals that depend on them.

Biological Diversity
Forests can be valuable reservoirs for biological diversity of plants and animals. Forests that sustain several plant and animal species are more diverse than forests with fewer species. The level of forest diversity affects how well a forest responds to disturbances like fire, diseases or insects, and the number of common, rare, threatened, and endangered species that live in it. Forests may also contain features identified and protected by the ***Natural Heritage Information System,*** such as rare plants or animals, animal breeding or nesting grounds, or unique geological features.

Cultural Resources
Forests contain important cultural or historic resources such as historic burial grounds or treaty-signing sites, large or very old trees, and tracts of old-growth forests. Archeologists identify these areas to protect and preserve them.

Water and Air Quality
Forests help keep water and air clean. The duff and vegetation on the forest floor slow water on its journey to streams and lakes, helping to minimize runoff, erosion, and pollution. Roots reduce soil compaction and trap pollutants that may reach rivers and groundwater. Trees remove carbon dioxide, ozone, nitrogen oxides, and sulfur dioxide from the air and release oxygen. Trees clean the air of particulate matter such as dust, pollen, and smoke by providing surfaces the particulates can cling to.

Carbon Sequestration
Through the process of photosynthesis, living trees and forests sequester or store carbon dioxide (CO_2) by absorbing it from the air and storing it in their roots, stems, branches, and foliage. Too much atmoshperic CO_2 contributes to higher global temperatures that could increase the frequency of extreme weather events and have a profound impact on human health. As trees decay, die, or burn, they release CO_2 back into the atmosphere. A tree harvested and reused as lumber, furniture, or other durable goods can hold its carbon for decades or longer. As long as yearly growth exceeds the amount of carbon removed during harvest, forests can slow the rate of CO_2 released into the atmosphere.

Minnesota DNR

Recreation
Forests provide opportunities for recreation and tourism, including hunting, horseback riding, hiking, fishing, birding, berry picking, camping, cross-country skiing, snowmobiling, and all-terrain vehicle use.

Fire: Enemy or Friend?

After commercial harvesting peaked in the late 19th century, by the early 20th century, huge fires fed by fuels left behind by loggers destroyed thousands of homes, businesses, and lives. As a result, the U.S. Forest Service's earliest policy was to suppress all fires.

This policy may have saved lives and property in the short term, but it had some unfortunate long-term consequences. It allowed dense undergrowth to fill in beneath the canopy, creating fuel. When fires did burn, they burned with tremendous intensity that scorched canopies and burned the soil, caused serious reductions in soil fertility, killed beneficial soil bacteria and fungi, killed overstory trees, increased soil erosion, and damaged wildlife habitat. Therefore, suppressing fires in fire-dependent areas may create old-growth forests that may be considered unhealthy.

Today, we recognize that small, low-to-the-ground, cool, frequent fires provide many environmental benefits, such as reducing competition, encouraging regeneration of trees, improving soil fertility, and increasing fire-loving species like blueberries and jack pine. We still suppress wildfires to protect human lives and property. But forest managers also work to replicate the beneficial fires of the past by controlling the amount of fuel in the forest through logging, allowing some fires to burn, and setting intentional fires called ***prescribed burns.***

Aesthetics

Forests also add beauty to our surroundings. Trees bring color and texture into the landscape, soften hard lines of buildings and paved areas, reduce vehicle noise, and provide feelings of peace and security. More than ever before, forest owners acknowledge not only the aesthetic value of the forest—but also the value of its nonmonetary existence—as having worth.

Energy From Woody Biomass

Biomass energy comes from any renewable organic matter (trees, plants, and associated residues) that can be burned to generate heat or electricity. Minnesota is looking into trees and other plants, along with wind power and other renewable sources of energy, to reduce our dependency on energy-derived nonrenewable resources like coal and oil.

Urban and Community Forests

When we hear the word *forest,* many of us think of wild settings, far-reaching stands of trees largely unbroken by human meddling. Some of the toughest challenges in forestry today, however, come from what is known as "urban forests"—the collections of trees that grow within city limits. City trees have to put up with more pollutants in the air than do rural trees. Their trunks and branches get gouged and broken. Their roots suffer from soil compaction, severing from construction, vandalism, and other problems. Urban foresters work hard to keep trees healthy in this challenging habitat by choosing the right trees for the setting and ensuring they receive the care they need to stay healthy.

Be careful when working around trees!

It is the fine root hairs of larger roots that absorb most of the water taken in a by tree. In many trees, most root hairs are 6–12 inches from the surface of the soil. Compacting soil with heavy equipment or covering a tree's roots with too much soil or mulch can actually cut off the tree's water and air supply enough to kill it. Intensive digging or rototilling around the base of a tree can also have drastic negative effects on the tree's health and ability to withstand future stress. Remember, much of the tree is underground!

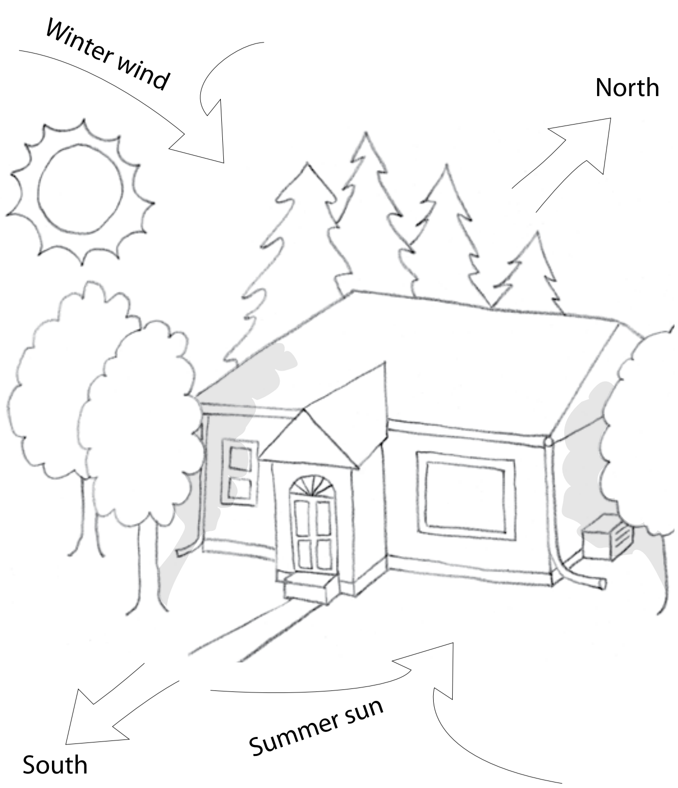
Why bother? Well, most people in Minnesota live in cities and towns, and trees are a valuable component of the urban environment for many reasons:

Economic Benefits

Trees add value to residential property. The U.S. Forest Service estimates that each mature tree "pays us back" from three to four times the cost of planting and maintenance over its lifetime. This payback comes in the form of cost savings due to preventing soil erosion, conserving energy, cleansing air and water, slowing and storing storm water, and increasing property values.

Energy Savings

By providing shade in the summer and shelter from the wind in winter, trees can reduce annual energy consumption in homes and office buildings by 20 percent or more. Many property owners in cities and suburbs plant trees strategically to shelter their homes and businesses from wind in winter and sun in summer, reducing energy demand for heating and cooling.



Properly planting trees around buildings saves energy costs from heating and cooling. Plant coniferous trees on north or northwest sides to block cold winter winds; deciduous trees on east and west sides to block hot summer sun and allow warm winter sun.

Clean Air

Trees release oxygen while trapping dust and removing pollutants. In fact, the average tree absorbs 10 pounds of pollutants from the air each year, including 4 pounds of ozone and 3 pounds of particulates. A single acre of trees uses up to 6 tons of carbon dioxide—the primary gas blamed for global warming—each year.

Clean Water

One hundred mature trees catch about 77,000 gallons of rainwater each year. Wooded areas and trees influence water flow, filtration, runoff, soil erosion, and sediment control, and provide clean water. Wooded areas also increase water percolation and infiltration, which is especially important to communities that depend on groundwater. Along streams, tree roots slow water flow and create pools where fish and other water creatures can lay their eggs.

Tree City U.S.A.

You may have driven into a town with a "Tree City" designation on its welcome sign. The National Arbor Day Foundation bestows this honor on communities that:

- Establish a tree board or department.
- Pass a tree care ordinance.
- Establish a community forestry program with an annual budget of at least $2 per capita.
- Organize an Arbor Day observation and proclamation.

Minnesota already has more than 120 Tree Cities. To learn more, go to www.arborday.org, or telephone 888-448-7337.

Health and Social Benefits

Trees' beauty and grace adds much to urban vistas, softening the harshness of cold, angular concrete and brick. Wooded areas in urban settings provide a place of mental and physical contentment. Research has shown that a walk in a wooded area can relieve psychological and emotional stress. Medical studies indicate that patients recover faster in facilities surrounded with trees and rooms offering views to wooded areas because they feel serene, peaceful, and restful. In addition, trees offer aesthetic values, recreational and educational opportunities, screening and privacy, and reduce noise and glare. Dr. Frances E. Kuo, and Dr. W.C. Sullivan at the University of Illinois at Urbana-Champaign found that trees in urban areas:

- Make people feel more calm and friendly
- Increase neighborliness
- Reduce symptoms of attention deficit hyperactivity disorder in children
- Help older teens resist negative peer pressure
- Reduce crime
- Reduce driving stress
- Slow traffic and make roads safe
- Improve physical health of residents

Vegetation has been shown to alleviate mental fatigue, one of the precursors to violent behavior. And because green spaces are used more, there's a sense that there are more eyes on the street, which may deter would-be criminals from committing crimes where they think they are being watched.

To sum up

Chapter Five: Forests Today

- Today, aspen is one of the most common trees in Minnesota.
- Today, there exists programs to preserve old-growth forests, regenerate white pine, and ensure a legacy of forests into the future.
- The public owns most of Minnesota's forests.
- Forests are used for timber, nontimber products, jobs, wildlife habitat; as reservoirs of biological diversity and cultural resources; and to improve air and water quality, carbon sequestration, recreation, aesthetics, and energy from woody biomass.
- Old-growth forests are designated and managed for long-term study.
- Urban and community forests provide critical benefits where people live.

"The idea that wilderness areas will take care of themselves if we just keep people out... that's an old model of wilderness management."
—Dr. Lee Frelich, University of Minnesota

CHAPTER SIX FORESTS TOMORROW

Can You Love the Earth and Cut Trees Too?

Minnesota's trees have great value as a part of the natural environment of our state. They also have great value as a key part of our industrial base. How can we appreciate trees as part of an ecosystem and harvest them, too?

The answer lies in balance, judgment, and wisdom. With more than 6.5 billion humans on this planet, there is no way we can avoid impacting the natural resources around us. (Every time we breathe we use part of the resource we call the atmosphere!) The key, from an environmental standpoint, is not to avoid using resources, but to use them mindfully in a way that minimizes the impact on the global ecosystem.

Why is it important to use renewable resources?

Renewable resources are just that—renewable! Nonrenewable resources such as gasoline disappear when used up. When renewable resources such as wood and plant material are disposed of and burned, the carbon dioxide (CO_2) they release equals the amount of CO_2 they absorbed during their relatively short lifetime. When nonrenewable resources such as oil and coal are burned, they release all at once CO_2 that was absorbed millions of years ago. Finally, renewable resources like trees provide many environmental, health, and economic benefits while alive, such as providing cleaner air, shade and cooling, food, habitat, aesthetics, protection from wind, and more.

When we look at things in this "big-picture" frame, harvesting Minnesota's timber begins to look like an earth-wise thing to do. Dr. James Bowyer, the University of Minnesota professor emeritus quoted at the beginning of Chapter 5, suggests that when we look at the environmental impact of harvesting Minnesota's trees, we need to also look at the environmental impact of NOT doing so.

Say we were to stop harvesting Minnesota's trees tomorrow. It's unlikely that we would at the same time stop using paper, sitting in chairs at tables, living in houses, and doing all of the other things that depend on the use of resources. Rather, we would turn to other resources. Each of these, whether wood from another region (such as Asia or South America) or substitutes such as plastics that are made from nonrenewable resources, has its own environmental costs, from initial production to transportation over long distances to eventual disposal.

The use of Minnesota's well-managed and maintained forest resource eases the pressure to harvest other ecologically more valuable forests such as tropical rain forests or the old-growth forests of the Pacific Northwest. It also keeps tree harvesting in an area where forests are scientifically managed as a renewable resource rather than cut and abandoned.

Also, as we have learned, not harvesting can lead to unhealthy, overcrowded, fire- and insect-prone forests. Today's forest managers have learned not only lessons from the days of over-ambitious loggers, but also from ecological records and American Indians showing that frequent, small fires and harvests can actually improve forest health.

Future Trends Will Affect Forests

Since trees' lifetimes are measured in decades rather than years, what we do—or don't do—now will make waves for a century or more. A number of trends today stand to influence Minnesota's trees in the 21st and 22nd centuries.

Changing Forest Products Industry

Like many other industries, global markets and competition drive the forest products industry. In fact, companies headquartered outside of the United State currently own many of Minnesota's major forest products mills. Competition for new investments also occurs globally, both among and within global corporations. Decisions to invest in a location such as Minnesota are based on many factors, such as available natural resources, raw materials, labor costs, and distance to markets. Providing a sustainable and reliable source of competitively priced wood will be key in attracting new forest products investments in Minnesota. Doing so means we must balance values and uses of public forest lands, and encourage private landowners to manage their lands to address these goals, too. Without new investments, Minnesota's forest products industries will struggle, and landowners may find that harvesting timber is no longer a cost-effective way to manage their forests.

Changing Forest Ownership

Timber and mining companies are selling thousands of acres of northern forest to timber investment corporations that use the land to make money. Sometimes, this means land may be sold in smaller parcels to several landowners rather than managing the forest to supply trees or wildlife habitat. At the same time, private, nonindustrial landowners are aging and their children are less interested in maintaining family homesteads. In both cases, Minnesota forests risk being sold, converted into smaller parcels, and developed. This compromises their ability to provide valuable unfragmented wildlife habitat, a sustainable source of timber, and recreational opportunities. In the future, fewer acres of forest land may be available to provide the same values and goods we receive from today's forests.

Forest Certification

Certification is an increasingly popular way to support sustainable forest management. Certification provides independent verification that land is being managed sustainably—in a way that meets today's needs without harming its ability to meet future needs. Lands become certified through periodic inspections by a qualified inspector who does not own the forest land. The Minnesota Department of Natural Resources earned certification for 4.9 million acres of state forest lands in 2006. Numerous counties and forest industry companies also have been certified or are pursuing certification of the forest lands they manage. Because some companies,

Internationally recognized logos from the Forest Stewardship Council and the Sustainable Forestry Initiative.

When you buy wood, or items made from wood, do you know where it came from? Often, retailers and consumers choose to buy wood from the cheapest source. However, the "cheapest" wood in terms of price may actually be the most expensive wood in terms of environmental costs. The price on the shelf depends on the cost of the tree in the state or country it came from, cost of transportation, and cost of manufacturing. If the wood came from Minnesota or other area that uses sustainable forest practices, you can be sure it was harvested from a well-managed forest. If the wood came from South America, Asia, or other regions, management standards may differ. In Minnesota, most state-administered lands are ***certified.*** Certified wood from lands managed by the DNR means that the DNR's forest management exceeds internationally recognized certification standards like the Forest Certification Council (FSC) and the Sustainable Forestry Initiative (SFI). Certification ensures the wood has been harvested with considerations toward forest health, wildlife, water quality, and future reseeding or replanting. Some retailers like IKEA or Time-Warner have required that certain percentages of its products be produced using certified wood. (In Time-Warner's case, 80 percent.) Retailers label certified wood so consumers know when their lumber, plywood, paper, or furniture has come from a well-managed source. And as more consumers demand environmentally friendly products, more retailers will offer them.

like The Home Depot, require that a certain proportion of the wood or paper pulp they buy is certified, Minnesota's forest market competitiveness improves when forest lands are certified.

Climate Change

Scientists expect Minnesota's climate to change in the years to come because of atmospheric changes caused largely by combustion of fossil fuels. This change will have implications for Minnesota's forests. Although there is much uncertainty regarding actual impacts, changing climate is expected to alter forest composition, tree growth, pest distribution, and populations of plants, mammals, birds, and pests inhabiting the forest. Certain tree species (e.g., oaks, maples) are expected to increase while others (e.g., spruce, fir, white pine) are expected to decrease. According to the U.S. Department of Agriculture, one acre of forest absorbs (or sequesters) 6 tons of carbon dioxide and produces 4 tons of oxygen each year. This is enough to meet the annual needs of 18 people. Because carbon dioxide is a significant contributor to global climate change, future forest landowners may be able to participate in carbon credit offset programs. These programs allow forest landowners to trade credits and collect income from the amount of carbon dioxide the trees on their land absorb. Carbon offset programs for forests can also give landowners financial incentives to engage in sustainable forest management, support local natural resources economies, and preserve family lands.

Biomass Energy

Due to the rising costs of fossil fuels, interest is growing to produce and use more energy from renewable sources, including plants and wood. Emerging technology is likely to expand biomass energy options to include broader applications of woody biomass, including tree plantations, residue from timber harvests, and brush.

Urbanization

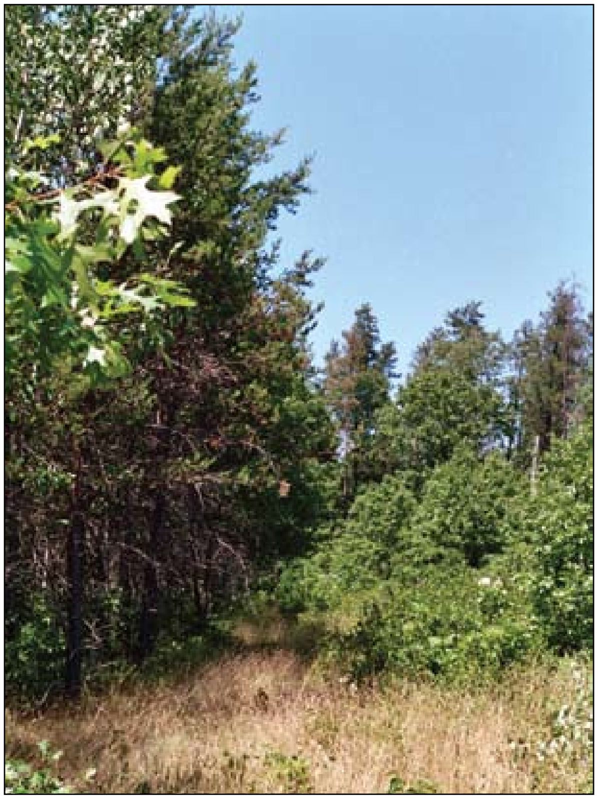
As human populations expand, pressure builds to cut more timber and build more houses, hospitals, shopping areas, and roads. All of these activities, if unchecked and uncoordinated, can fragment forests and habitats into smaller pieces and hinder movement of plants and animals from one area to another. Also, as more roads thread deeper into forests, the added threat of damage from illegal recreational use increases.

All-Terrain Vehicles

Motorized use of state forest lands has grown in recent years. This has led to some concerns about overuse and resource damage. The Minnesota Department of Natural Resources is working to accommodate all-terrain vehicle use on state lands without displacing nonmotorized forest users or harming habitat.

White-Tailed Deer

While white-tailed deer are native to Minnesota, in times before European settlement their numbers were far fewer than they are today. Deer populations tend to increase in milder winters and when humans create more deer-friendly habitat. Deer prefer forest edges, which are created by natural disturbances like fire and windthrow, but also from timber harvesting, roads, homes, and other development. The consequences of high deer populations are heavy browse damage on new growth of white pine, cedar, and other saplings, from which many forests are unable to recover without human help.



Minnesota DNR

In this photo, jack pine seedlings were planted in all areas at the same time. On the left, a deer exclosure (fence) protected the seedlings and they grew to maturity. The area in the foreground was not protected and the deer browsed it away.

CHAPTER SIX

Invasive Plants and Animals

Minnesota forests are facing invasions from a growing number of nonnative, invasive forest pests. Three factors are increasing the potential for exotic pests to threaten the health of native plant communities in our state:

- More people entering forest lands
- Increasing interstate and international commerce
- Changing climate

Earthworms

Steve Mortensen

All terrestrial earthworms are nonnative, invasive species from Europe and Asia. (There is a native aquatic species that woodcock eat.) Earthworms arrived with European settlement and are often spread when moving soil or depositing live fishing bait. Worms are natural decomposers and can aerate soils. Many people add worms to compost piles. However, when worms escape into forests, earthworms devour the ***duff*** on the forest floor and reduce nutrients in the soil. Many plants suffer, such as trilliums or the endangered goblin fern that relies on duff as a growing medium and source of nutrients. Studies conducted by the University of Minnesota and forest managers show that at least seven species of worms are invading our hardwood forests and causing a loss of tree seedlings, wildflowers, and ferns. In areas heavily infested by earthworms, soil erosion and leaching of nutrients may reduce the productivity of forests. Because many areas of the state are still free from earthworm disturbance, and because earthworms are nonnative, it is illegal to release them into the wild. Minnesota Statutes, section 84D.06 requires anglers to dispose unwanted bait in the trash, not in the soil or water.

Buckthorn

Jan Samanek, State Phytosanitary Administration, Bugwood.org

European buckthorn was introduced into the United States in the 1920s. Planted as a shrub, buckthorn can grow to the size of a small tree, thrives in all regions of Minnesota, and is an aggressive invader. Once it invades a forest, buckthorn quickly crowds out natural vegetation, greatly reduces or eliminates regeneration of native trees, and decreases the animal and plant diversity.

Emerald Ash Borer

David Cappaert, Michigan State University, Bugwood.org

The emerald ash borer is an insect native to Asia and has the potential to kill all ash trees in Minnesota. It was found in the eastern United States in 2002 and is expected to arrive in Minnesota soon. The adult beetles lay eggs on the bark, which hatch into larvae that bore into the tree. The larvae tunnel through the phloem layer and disrupt the movement of water and nutrients, eventually killing the tree.

Plans for Future Forests

In response to past actions and future needs and conditions, managers make plans to ensure forest health and benefits into the future.

Don't Move Firewood

To prevent damaging insects such as emerald ash borers, Japanese bark beetles, or gypsy moths from entering the state, always buy wood from an approved Minnesota firewood vendor, buy it where you burn it, and burn all of it where you buy it.

Assessing Trees and Forests

By congressional mandate, the U.S. Forest Service periodically inventories the nation's forest land, regardless of owner. The Minnesota DNR inventories state-owned lands in Minnesota. Field foresters do inventories using tools such as:

- Clinometers to measure tree height
- Diameter tapes to measure tree diameter
- Prisms to estimate the number of trees large enough to be considered valuable on an acre
- Global positioning system (GPS) units to record locations

The Minnesota DNR has helped the U.S. Forest Service conduct the past six inventories (1936, 1953, 1962, 1977, 1990, and 2003). When foresters, hydrologists, wildlife specialists, and others inventory a large area, it gets a designation determined by the number of similar plants, animals, soils, topography, and water features in the area. This designation is called an ***ecological classification.*** Computer experts compile the information into maps. Planners, scientists, and others use the maps to study forest components and make decisions about current and future forest and wildlife management.


Minnesota DNR

A forester estimates tree height using a clinometer.

How Minnesota's Forest Land Is Measured

In Minnesota, land use and land cover are measured in a variety of ways. Land ownership records, U.S. Forest Service's Forest Inventory and Analysis (FIA) assessments, and the Minnesota DNR's Cooperative Stand Assessment data all yield different numbers. In addition, forest land and timberland are defined differently.

Here are some numbers commonly used to describe the extent of Minnesota's forested land:

- 54 million acres comprise Minnesota's land base, including water. *Source: Minnesota Land Use and Cover: 1990s Census of the Land*
- 51 million acres comprise Minnesota's land base, not including water. *Source: Minnesota Land Use and Cover: 1990s Census of the Land*
- 16.3 million acres in Minnesota are considered forest land. *Source: Minnesota Forest Inventory and Analysis (FIA) 2005 data*
- 15 million acres of Minnesota's forested land are considered timberland. *Source: Minnesota Forest Inventory and Analysis (FIA) 2005 data*
- 5.6 million acres of Minnesota's land base are administered by the DNR. *Source: DNR Division of Lands and Minerals—Land Records System 2003*
- 4.5 million acres of land administered by the DNR are considered forested. *Source: Cooperative Stand Assessment Data*

Forestry Careers

People with many kinds of talents and skills are needed to keep forests healthy and productive. The future will require even more people to work in forest-related careers. People with forestry-related careers include:

- Forest economists (assess best ways to use and market trees)
- Timber specialists (assess best ways to harvest and manage forests)
- Forest planners, Geographic Information Systems (GIS) specialists (plan and map out forests and the plants and animals that live in them)
- Ecologists (study forests and the interactions among living and nonliving components)
- Loggers (cut timber)
- Foresters (measure and inventory timber and forests)
- Paper/pulp mill workers (make paper from wood pulp)
- Policy advisors, consultants, or liaisons (affect forestry policies)
- Sawmill workers (make lumber)

- Craftspeople (make products from wood)
- Scientists (study trees and forests)
- Urban foresters (manage trees in urban settings)
- Arborists (take care of tree health)
- Nursery workers (grow and nurture seedlings)
- Recreation specialists (manage campers, off-road vehicle enthusiasts, hikers, and other recreational users in a forest setting)
- Hydrologists (study water in the forest), biologists (study wildlife in the forest), and botanists (study plants in the forest)
- Educators (teach about trees)

Encouraging young people to consider careers in forestry and other natural resources is critical to maintain healthy resources into the future. A good way to start is to give young people frequent opportunities to explore the natural world that will strengthen a love and respect for the land and the natural resources it provides.

Interview With a Forester: Rebecca Barnard

Forestry requires an interest in science, natural resources, the outdoors, and community. An average day may involve inventorying tree and plant species, measuring trees, meeting with a logger on a timber sale site, working with private landowners and suggesting management options, teaching school-age children and public citizens about forestry, attending public and/or legislative meetings, or fighting wildfires. I enjoy the challenge of applying scientific principles to our everyday life, while improving people's understanding of forestry and managing for healthy forests.

What Can You Do?

Plant Trees

Each new tree that graces our landscape is a new source of beauty, oxygen, shade, and habitat for creatures of all sizes and sorts. An investment in a tree is an investment in the future. Appendix 1 provides advice on how to plant seedlings and trees.

Keep Trees Healthy

Plant, water, and prune carefully. Remove invasive exotic plants. Be careful not to transport pests and diseases from one place to another (for example, in infested or diseased firewood).

Keep Forests Healthy

Consider NOT mowing or paving all property around your home, school, church, business, and city parks. Retaining forested areas costs less, saves energy, provides needed green space for communities and wildlife habitat, and may even reduce crime!

Protect the Forests You Own

If you own forest land, consider strategies for permanent land protection, such as conservation easements, land exchanges, and other options.

Rethink, Reduce, Reuse, Recycle

Choose to use renewable resources over nonrenewable resources, buy items with reduced or "green" packaging, and avoid buying unnecessary products.

Remember the Balance

Conservation does not mean "Never cut a tree!" It's true that we can harm this resource if we use it without concern for the future. But our forests will be healthiest if we balance human uses with the other values of the resource.

Be a Teacher

Everyone can teach neighbors, friends, and, most importantly, the next generation how to be good stewards of Minnesota's forests and sustain a healthy way of life.

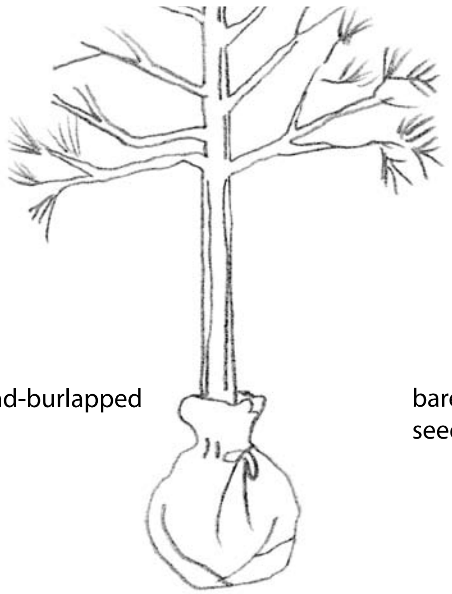
To sum up

Chapter Six: Forests Tomorrow

- Forests are an important renewable resource.
- Future trends will affect forests: changes in the forest products industries, changing forest ownership, forest certification, climate change, biomass energy, urbanization, motorized recreation, deer, and invasive plants and animals.
- Foresters measure the number and health of trees to manage forests for the future.
- There are many forestry-related careers.

APPENDIX ONE HOW TO PLANT SAPLINGS AND SEEDLINGS AND CARE FOR A TREE

balled-and-burlapped sapling



bareroot seedling

containerized seedling

Roots of saplings are contained in a ball of soil, wrapped in burlap, and secured with string.

Roots of seedlings are bare but contained in plastic bags with wet newspaper, foam cells, or other container to prevent roots from drying out.

Roots of containerized trees are in a ball of soil encased by a removable container.

How to Plant a Sapling (Young Tree)

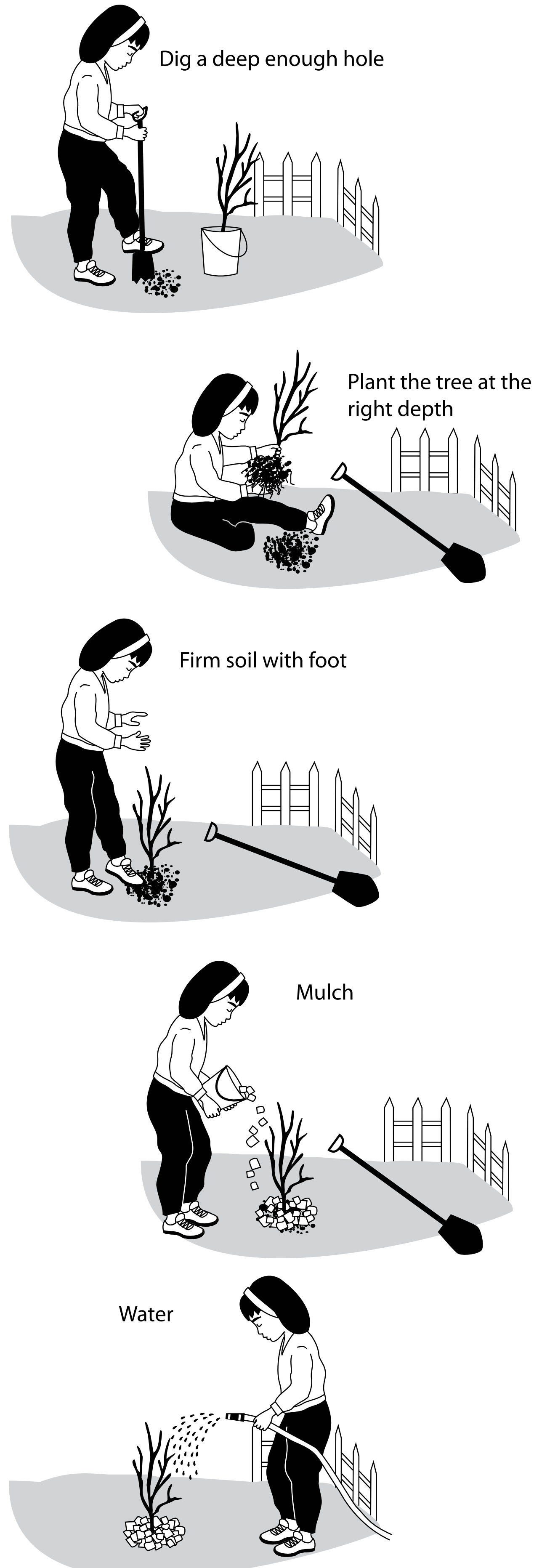
Saplings are young trees with a diameter of 1 to 5 inches at a point that is 4½ feet from the ground. Saplings may be balled and burlapped, bareroot, or containerized.

1. Choose a good spot for your tree. Don't forget its ADULT size.
2. Keep the roots moist all the time. Dry roots die.
3. Check for underground gas and utility lines before you dig! (Call the Gopher State One-Call at 651-454-0002 or 1-800-252-1166.) Measure the root ball, then dig a hole two to three times as wide as the root ball and as deep. If roots are container-bound, make a few cuts on the underside of the root ball and make sure to cut out any roots that encircle the root ball. Clip out any damaged roots.
4. Plant the tree at the right depth. In nature, tree roots begin at or just beneath the soil surface, and so should your newly planting sapling. Remove the excess soil until you find the first main root before you plant the tree. Planting the first root at or slightly below the soil surface is the correct planting depth. Remove any synthetic wrappings or fastenings, and pull the burlap away from the stem. If the burlap is tan or brown colored, you may leave it on the rest of the soil ball since this burlap will rot away in a month. If the burlap is green, remove as much of it as possible, or loosen it at the top and roll it back into the hole. Green burlap is treated to resist decay and can retard new root growth.
5. Add more soil and firm with your foot to remove air pockets.
6. Mulch with wood chips. Place chips 3 to 4 inches deep and spread from trunk out to drip line. Keep a small gap between the chips and the trunk to avoid diseases and fungi.
7. Remove any synthetic labels and tags.
8. Water the tree. (See "How to care for a newly planted tree" on page 45.) Wait for shade!

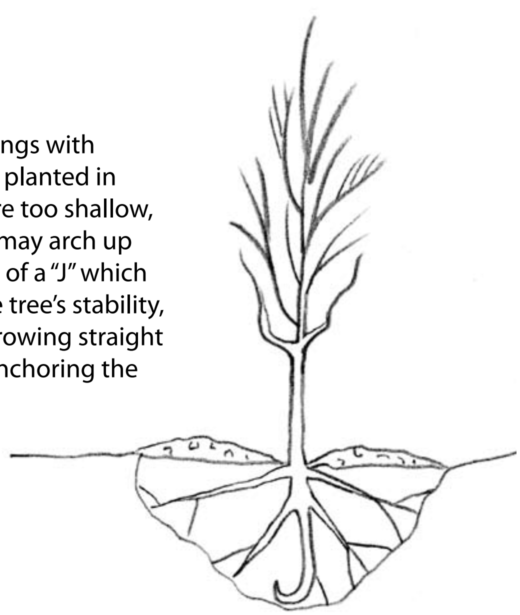
How to Plant Tree Seedlings

Seedlings are young trees with a diameter of up to 1 inch at a point that is 4½ feet from the ground. Seedlings are usually bareroot.

1. Plant the seedling as soon as possible. If planting must be delayed a few days, keep the plants in a cool (38–45°F), protected place with air circulation, like a refrigerator or unheated barn. Keep out of rain and wind. Keep roots damp, but allow excess water to drain. In cool, damp weather, the biggest threat to these trees is from mold.
2. Choose a good spot for the seedling. Check for underground gas and utility lines before you dig. (Call the Gopher State One-Call at 651-454-0002 or 1-800-252-1166.) Consider its adult size.
3. Brush aside loose organic material such as leaves and grass to expose soil. Don't let organic matter get into the planting hole where it can decompose and leave air spaces that may dry out the roots.
4. Plant seedling in ground quickly with roots straight down, not spread out. Make sure roots aren't curled or bunched up. When exposed, fine roots can dry out in less than a minute.
5. Place the first main root at or slightly below the soil surface.
6. Fill hole with loose soil to eliminate air pockets. Gently tamp with hands or feet to settle soil with water.
7. Mulch.
8. Water the tree!



When seedlings with taproots are planted in holes that are too shallow, the taproot may arch up in the shape of a "J" which weakens the tree's stability, instead of growing straight down and anchoring the tree.



How to Care for a Newly Planted Tree

Water deeply* and regularly. Water newly planted trees every 7-10 days. (One deep watering a week is enough.) Water the tree during dry periods for the first three years. Never give trees or shrubs a light sprinkling. It will encourage shallow root growth and may weaken the plant.

If trees are planted in fertile soil, no fertilizer is needed.

When you add mulch, do not place it next to the trunk of a tree where water can be trapped on the trunk and encourage rot, insects, or diseases.

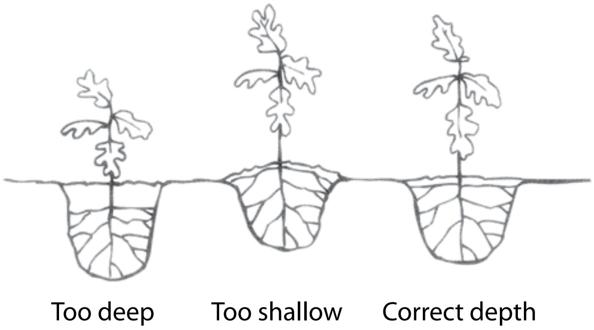
Stake only unstable newly planted trees. After one year, most stakes can be removed.

Prune broken, dead, or rubbing branches. Trim away any secondary or competing "leaders," but not the main leader! In most cases, applying a wound dressing isn't necessary. The best time to prune trees is when they are dormant and after the coldest part of winter. To prevent spread of disease, AVOID pruning oaks or elms during the growing season (April through July). Watch out for power lines!

For long-term tree care, refer to the "Forest Health Web Resources List" at www.mndnr.gov/treecare/forest_health.

Common Tree Planting Errors

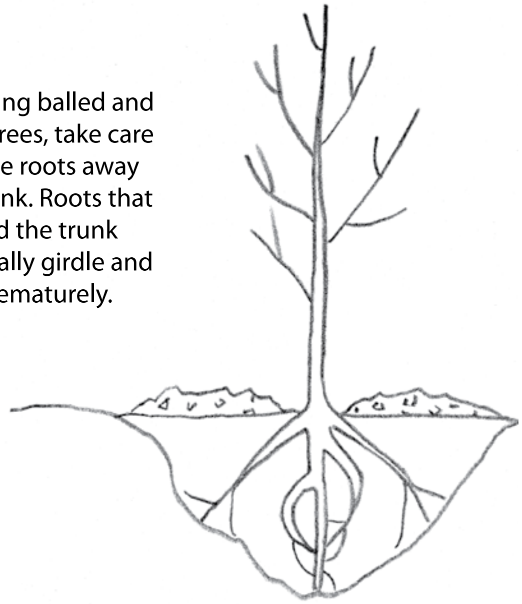
- Storing seedlings in a bucket of water for more than a few minutes
- Allowing roots to circle root ball
- Planting hole too small
- Planting too shallow or too deep
- Not allowing proper root spread
- Air pockets in the soil
- Allowing taproots of seedlings to turn up ("J" roots)
- Planting over rocks or in dry soil
- Planting a species unsuitable for the site
- Failing to mulch
- Not watering enough on a regular basis
- Not visualizing the tree's adult size



Tip

Unless you're planting a small shrub or street tree in a small, confined space, avoid amending (improving) the soil in the planting hole. The "good" soil will encourage the roots to confine themselves within that small area rather than spread out as they need to.

When planting balled and burlapped trees, take care to spread the roots away from the trunk. Roots that grow around the trunk may eventually girdle and kill a tree prematurely.



* "Deep watering" is defined as 1 inch of water. To measure the amount of water applied to tree roots, use a small water sprinkler over the root area. Place an empty tuna can or other container within the zone where water falls. When the water reaches 1 inch, turn off the sprinkler.

APPENDIX ONE

APPENDIX TWO MINNESOTA'S NATIVE TREE SPECIES

Below is a list of Minnesota's 52 native trees and the biome in which they occur. The symbol **D** denotes deciduous trees and **C** denotes coniferous trees. As you can see, several deciduous trees show up in the coniferous biome and vice-versa!

Common Name	Scientific Name	Tallgrass Aspen Parkland Biome*	Coniferous Biome*	Deciduous Biome*	Prairie Grassland Biome*
Ash, American mountain	*Sorbus americana*		D		
Ash, black	*Fraxinus nigra*		D	D	
Ash, green (also called red ash)	*Fraxinus pennsylvanica*	D	D	D	
Ash, northern mountain	*Sorbus decora*		D		
Ash, white	*Fraxinus americana*		D	D	
Aspen, bigtooth (also called largetooth aspen, poplar, popple)	*Populus grandidentata*		D	D	
Aspen, quaking (also called trembling aspen, poplar, popple)	*Populus tremuloides*	D	D	D	D
Basswood, American	*Tilia americana*	D	D	D	
Birch, paper	*Betula papyrifera*		D	D	
Birch, river	*Betula nigra*			D	
Birch, yellow	*Betula alleghaniensis*		D	D	
Box elder	*Acer negundo*	D		D	D
Butternut (also called white walnut)	*Juglans cinerea*			D	
Cedar, eastern red (also called juniper)	*Juniperus virginiana*		C		C
Cedar, northern white	*Thuja occidentalis*		C		
Cherry, black	*Prunus serotina*			D	
Cherry, pin	*Prunus pensylvanica*		D	D	
Coffeetree, Kentucky	*Gymnocladus dioica*			D	
Cottonwood, eastern	*Populus deltoides*			D	D
Elm, American	*Ulmus americana*			D	D
Elm, rock	*Ulmus thomasii*			D	
Elm, slippery (also called red elm)	*Ulmus rubra*			D	
Fir, balsam	*Abies balsamea*		C		
Hackberry	*Celtis occidentalis*			D	
Hemlock	*Tsuga canadensis*		C		
Hickory, bitternut	*Carya cordiformis*			D	
Hickory, shagbark (also called shellbark)	*Carya ovata*			D	

Common name	Scientific name	Tallgrass Aspen Parkland Biome*	Coniferous Biome*	Deciduous Biome*	Prairie Grassland Biome*
Honeylocust	*Gleditsia triacanthos*			D	
Hophornbeam, eastern (also called ironwood)	*Ostrya virginiana*		D	D	
Hornbeam, American (also called blue beech, muscle-wood)	*Carpinus caroliniana*			D	
Maple, black	*Acer nigrum*			D	
Maple, mountain	*Acer spicatum*	D	D		
Maple, red	*Acer rubrum*		D	D	
Maple, silver	*Acer saccharinum*		D	D	
Maple, sugar	*Acer saccharum*		D	D	
Mulberry, red	*Morus rubra*			D	
Oak, black	*Quercus velutina*			D	
Oak, bur	*Quercus macrocarpa*		D	D	D
Oak, chinkapin (also called yellow chestnut oak)	*Quercus muehlenbergii*			D	
Oak, northern pin (also called Jack oak, Hill oak)	*Quercus ellipsoidalis*		D	D	D
Oak, northern red	*Quercus rubra*		D	D	
Oak, swamp white	*Quercus bicolor*			D	
Oak, white	*Quercus alba*			D	
Pine, eastern white	*Pinus strobus*		C	C	
Pine, jack	*Pinus banksiana*	C	C		
Pine, red (also called Norway pine)	*Pinus resinosa*		C	C	
Poplar, balsam (also called balm-of -Gilead)	*Populus balsamifera*		D	D	
Spruce, black	*Picea mariana*	C	C		
Spruce, white	*Picea glauca*		C		
Tamarack (also called eastern or American larch)	*Larix laricina*	C	C		
Walnut, black	*Juglans nigra*			D	
Willow**	*Salix species*	D	D	D	D
Willow, black	*Salix nigra*	D		D	D
Willow, peachleaf	*Salix amygdaloides*	D	D	D	D

* A ***biome*** is a regional ecosystem characterized by the plant, animal, and microbial communities that have developed under specific soil and climate conditions. Minnesota is home to four biomes: coniferous forest, deciduous forest, prairie grassland, and tallgrass aspen parkland. The Minnesota Department of Natural Resources and U.S. Forest Service have developed a detailed Ecological Classification System (ECS) that outlines the parts of each of Minnesota's four biomes. (The ECS refers to biomes as ***provinces.***)

** Most willow species reach only shrub height. In Minnesota, only black and peachleaf willows reach tree height.

For more information on Minnesota trees, see www.mndnr.gov/trees_shrubs

APPENDIX THREE READING STORIES IN TREE RINGS

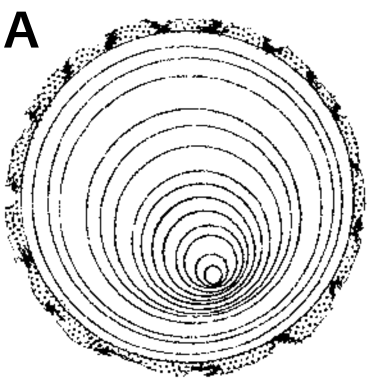
Each year, trees that grow in temperate regions (nontropical) create a layer of wood around the circumference of the trunk and branches. Rapid growth during springtime creates many xylem cells, which make a light-colored wood known as **spring wood.** As tree growth slows during the hot, dry summer, new xylem cells are laid more tightly and produce a darker circle of wood. This is often called **summer wood.** One layer of light-colored spring wood along with one layer of darker summer wood marks the passage of a year in the tree's life. Reading tree rings can give us clues as to former growing conditions, droughts, insect infestations, or fire.

Trained foresters who are familiar with the trees they work with can estimate a tree's age from its appearance. For the rest of us, the only way to know a tree's age is to get a cross section of the trunk. (Or you can ask a forester for a core sample, which gives you the same information without killing the tree.)

Generally, wide rings indicate years of vigorous growth, and may represent a season of abundant water, sunlight, nutrients, and space. Often, the rings laid on when the tree is a sapling are wider than growth in later years. Narrower rings indicate years of slower growth, and may represent a season of inadequate water, sunlight, nutrients, or space. Sunlight may change from one season to the next due to competition and shading from other trees, topography, or structures.

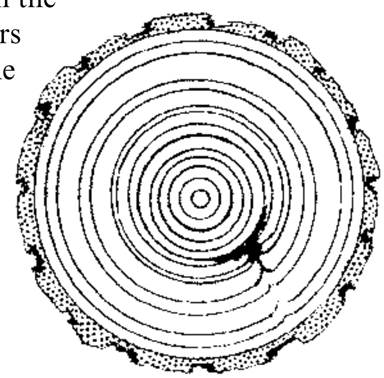
Sometimes you may notice a ring with wider growth on one side and narrower growth on the other (A). Competition from other nearby trees can cause this condition. Sometimes uneven growth rings result when one tree falls and leans against another live tree and the live tree grew more on one side to curve up around the fallen tree. Other explanations may include a tree growing on a slope or on slumping ground, or a windstorm may have pushed the tree to lean to one side. When that happens, the tree lays on thicker growth on the side closest to the ground in an effort to grow upright again.

A



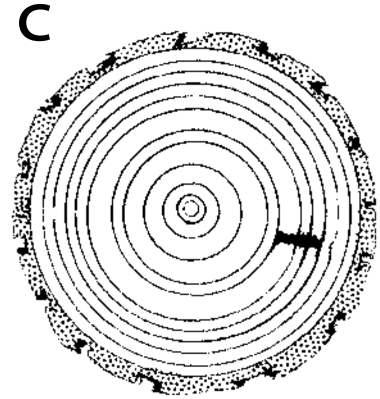
Trees record injuries in the form of scars (B). Scars on tree rings may come from fire, insects, or damage from machines like lawn mowers, earthmovers, or vehicles.

B



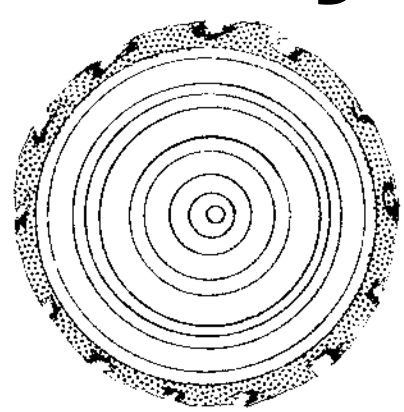
The mark beginning in year six (in C) is all that's left of a branch that died and fell off. Eventually, the tree's trunk grew around the remains of the branch and covered it.

C



Narrow and wide rings on the same tree (D) could have been caused by intermittent years of drought, insect damage, construction damage, or other disturbance. If a tree loses all or most of its leaves because of an insect attack or drought, it is not able to make food and grows very little that year. Root damage from the construction of a house or sidewalk too close to the tree reduces the water and minerals the roots can absorb.

D



Sometimes, people cut cross-section disks from the trunk of a tree or branch and then sand and varnish them to make the rings more visible. A sample cross section is often called a "tree cookie."

Are Big Trees Older Than Smaller Trees?

Just because a tree is large, don't assume that tree is older than a small tree. For example, a 50-year-old cottonwood can grow as tall as 100 feet and grow more than 300 inches in circumference, while a red maple tree of the same age could rarely match the cottonwood in circumference and height.

Studying tree rings is called ***dendrochronology.*** When foresters notice the outside rings of a tree beginning to narrow, this could be a sign that the tree's neighbors may be crowding it out.

Time to thin this forest. Notice the trees' rings are narrowing toward the outer edges.

Heart rot in American basswood.

Fire scar.

Photos courtesy of Eli Sagor

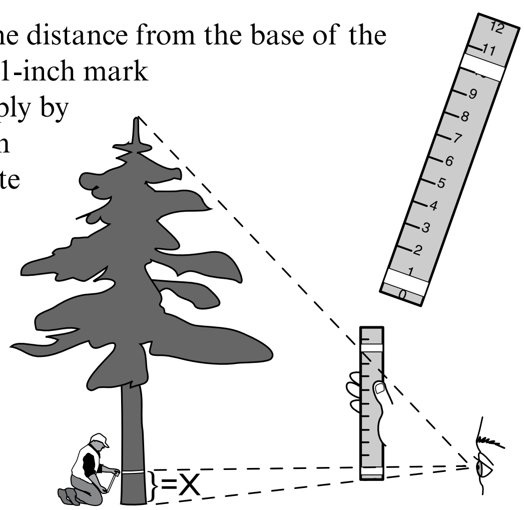
APPENDIX FOUR HOW TO MEASURE TREES

How High

The most reliable method to measure height uses a hand level, clinometer, or hypsometer. If these instruments are unavailable, use a ruler.

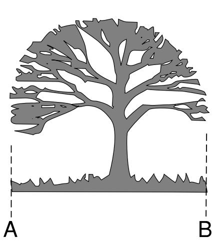
Take a 12-inch ruler and mark the 1-inch and 10-inch lines on the ruler with tape. Work in pairs. One person stands at the base of the tree. The other holds the ruler in front of his or her own eyes at arm length and moves back until he or she can see the whole tree from top to bottom between the 0-inch and the 10-inch mark on the ruler. He or she then moves the ruler until the base of the tree is exactly at 0 inches and the top of the tree is sighted exactly at 10 inches. Then he or she sights out from the 1-inch mark to a point on the trunk above the base. The partner marks this spot on the trunk with tape.

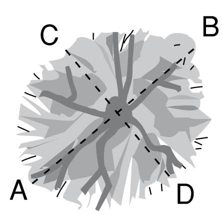
Measure the distance from the base of the tree to the 1-inch mark (X). Multiply by 10 to get an approximate idea of the height of the tree.



Crown Size

Set a stake directly under the outside edge of the crown farthest from the trunk (A) and another directly opposite it at the outer edge of the crown on an imaginary line passing through the center of the tree (B). Next, set stakes marking the shortest diameter of the crown passing through the center of the tree (C and D). Measure both distances to the nearest foot with a tape measure. Add the two measurements together and divide the sum by two to find the average crown spread.



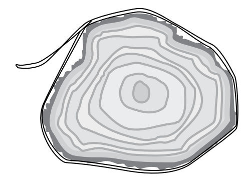


Around the Middle

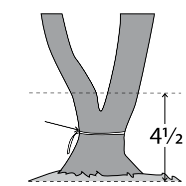
Measure, to the nearest inch*, the distance around the tree at a point 4½ feet up from the ground to get the circumference. Using the circumference, calculate the diameter ($d = C/\pi$). A flexible tape measure is a good tool to use. Measuring diameter at 4½ feet from the ground is an industry standard, also known as "diameter at breast height" or DBH.

How to find the circumference of hard-to-measure trees:

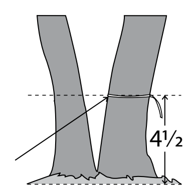
When a tree has deep convolutions or indentations, measure without pressing into the indentations.



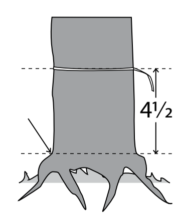
If a single tree has a double stem that forks below 4½ feet above the ground, measure at the narrowest place below the fork.



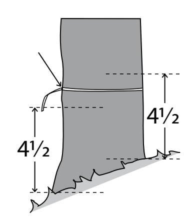
If the tree forks at ground level, measure the largest stem at 4½ feet.



When the base of a tree is "heaved" (tree roots exposed usually due to erosion, along with tree movement and growth patterns), the measuring point begins where the root mass ends and the tree trunk begins.



If a tree is growing on a slope, measure 4½ feet above the midpoint of the different ground levels.



* Rarely does a measurement fall exactly on a whole number. In most cases, we measure to the nearest inch, which is the whole number closest to the true measurement. For example, if the circumference falls between 10 and 11 inches, but is a little closer to the 11-inch mark, the circumference is 11 inches.

APPENDIX FIVE MORE INFORMATION

For All Citizens and Policy Makers

- *A Citizen's Guide to DNR Forestry,* Minnesota Department of Natural Resources (DNR) Available as a PDF on www.mndnr.gov/forestry/education
- *Big Tree Registry,* Minnesota DNR. PDF and nomination forms www.mndnr.gov/trees_shrubs/bigtree
- *Big Woods, Big Rivers Curriculum* (Draft II), Master Naturalist Program, University of Minnesota Extension, and Minnesota DNR, 2005. www.minnesotamasternaturalist.org
- *Conserving Wooded Areas in Developing Communities,* Minnesota DNR. Available as a PDF on www.mndnr.gov/forestry/urban
- Free maps, including topographic maps, aerial photos, forest inventory maps, and other natural resources-related Minnesota maps. www.mndnr.gov
- *Minnesota Conservation Volunteer,* bimonthly magazine from the Minnesota DNR. www.mndnr.gov/volunteer
- *MNTrees.org,* Web site developed by the Minnesota DNR. www.mntrees.org
- *My Minnesota Woods,* Web site developed by the University of Minnesota Extension as a source of advice for woodland stewards. www.myminnesotawoods.umn.edu
- Nowak, D.J., 1994, *Air pollution removal by Chicago's urban forest, in: Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project,* (E.G. McPherson, D.J. Nowak, and R.A. Rowntree, eds.) Gen. Tech. Rep. NE-186, USDA Forest Service, Northeastern Forest Experiment Station, Radnor, PA, pp. 63-82.

Minnesota Tree Identification Guides

- Rathke, David M. *A Beginners' Guide to Minnesota Trees,* University of Minnesota Extension, BU-6593, 1995.
- *Minnesota Invasive Nonnative Terrestrial Plants: An Identification Guide for Resource Managers,* Division of Trails and Waterways, Minnesota DNR, 2002.
- Rathke, David M. *Minnesota Trees,* University of Minnesota Extension, BU-0486, 2001.
- Symonds, George W.D., *The Tree Identification Book,* William Morrow and Company, Inc., New York, 1958.
- Symonds, George W.D., *The Shrub Identification Book,* William Morrow and Company, Inc., New York, 1963.
- Tekila, Stan, *Trees of Minnesota Field Guide,* Adventure Publishing, 2001.
- *Trees and Shrubs of Minnesota,* online identification guide, Minnesota DNR www.mndnr.gov/trees_shrubs
- *Trees of Minnesota,* Minnesota DNR, 1997. Available through Minnesota's Bookstore www.comm.media.state.mn.us/bookstore

For Homeowners

- *Backyard Conservation: Bringing Conservation From the Countryside to Your Backyard,* Natural Resources Conservation Service. Available as a PDF on www.nrcs.usda.gov/feature/backyard
- Information on tree care, planting windbreaks, and forest health on the Forest Resources Extension, University of Minnesota Extension, http://fr.cfans.umn.edu/extension
- *Keeping Your Home Firewise,* Minnesota DNR www.mndnr.gov/firewise
- Pellet, Harold; Rose, Nancy; and Eisel, Mervin, *The Right Tree Handbook,* University of Minnesota Extension, St. Paul, Minnesota, 1991.
- *Minnesota SWCD Forestry Association Tree Handbook,* Minnesota Soil Water Conservation District www.maswcd.org/Partner_links/tree_care_handbook.pdf
- Minnesota Tree Planting Handbook, University of Minnesota http://cfc.cfans.umn.edu/links/handbook.pdf
- *The Right Tree for the Right Place,* National Arbor Day Foundation www.arborday.org

For Forest Landowners

- Allman, Laurie, *Land Protection Options: A Handbook for Minnesota Landowners.* The Trust for Public Land, The Nature Conservancy, the Minnesota DNR, and the Minnesota Land Trust (revised, 2000).

- Baughman, Melvin J.; Alm, Alvin A.; Reed, A. Scott; Eiber, Thomas G.; and Blinn, Charles R.; *Woodland Stewardship: A Practical Guide for Midwestern Landowners,* University of Minnesota Extension, Minnesota DNR, and the Forest Stewardship Program, 1993.
- Haygreen, John G. and Bowyer, Jim L., *Forest Products and Wood Science: An Introduction,* 3rd edition, Iowa University Press 1996.
- The Minnesota Woodland Advisor Program trains volunteers about forest stewardship and how to teach others to care for forests. The program is offered as a partnership among the University of Minnesota Extension, the Minnesota Forestry Association, the Minnesota DNR, local woodland committees, and other groups. Visit http://cfc.cfans.umn.edu/wa
- *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines,* 2005, Minnesota Forest Resource Council. Available as a PDF on www.frc.state.mn.us/FMgdline/Guidebook.html

For Resource Managers

- *Field Guide to the Native Plant Communities of Minnesota: The Eastern Broadleaf Province,* State of Minnesota, Minnesota DNR, 2005. www.mndnr.gov/nr
- *Field Guide to the Native Plant Communities of Minnesota: The Prairie Parkland and Tallgrass Aspen Parkland Provinces,* State of Minnesota, Minnesota DNR, 2005. www.mndnr.gov/nr
- Map: *"Presettlement Vegetation of Minnesota,"* based on Francis J. Marschner's 1930 original analysis of 1847–1907 Public Land Survey notes and landscape patterns. Marschner compiled his results in map format, which was subsequently captured in digital format.
- Web site on Minnesota's forest types, health, fires, tree identification, and more www.mndnr.gov/forestry

For Teachers

- Project Learning Tree is an award-winning, teacher-written interdisciplinary curriculum consisting of a suite of activity guides designed to teach students forestry and environmental education. Teachers must attend a workshop to receive the activity guides. In Minnesota, a workshop calendar is maintained at www.mndnr.gov/plt.
- The School Forest Program is an option for schools that want to establish an outdoor forest classroom. For more information, see www.mndnr.gov/schoolforests.

- *Teachers' Guide to Arbor Month: Activities on Trees and the Natural World for Grades K-8,* 2002, Minnesota Arbor Month Partnership. Available as a PDF on www.mndnr.gov/arbor-month
- Tester, John R., *Minnesota's Natural Heritage: An Ecological Perspective.* 1995. University of Minnesota, St. Paul, Minnesota.
- The Web site, www.mndnr.gov/forestry/education, contains links to posters, activity guides, and tree identification profiles available from the Minnesota DNR, including:
  - *A Place for Every Tree* poster and text, Division of Forestry, Minnesota DNR, 2007.
  - *Biomes of Minnesota* poster and text, Division of Forestry, Minnesota DNR, 2008.
  - *Minnesota Forest Treasures* Poster, Division of Forestry, Minnesota DNR, 1999, 2005.
  - *Trees for All Seasons* poster and text, Division of Forestry, Minnesota DNR, 2006.
- *The Story of Minnesota's Forests* poster and text, Minnesota Forest Industries, 2006. www.minnesotaforests.com

GLOSSARY

Abiotic – (adj.) Not relating to, or caused by, living organisms.

Abscisic acid – (n) One of five classes of plant hormone that inhibits shoot growth, closes stomata, and induces and maintains seed dormancy.

Abscission – (n) The natural separation of flowers, fruit, or leaves from a plant at a special separation layer of cells called an ***abscission layer.***

Anthocyanin – (n) Any of various pigments producing blue to red coloring in flowers and plants.

Biome – (n) A major ecological community type (as tropical rain forest, grassland, or desert). Ecologists refer to biomes as ***provinces.***

Biotic – (adj.) Relating to, or caused by, living organisms.

Board foot – (n) The amount of wood in a board that is 1 inch thick, 12 inches long, and 12 inches wide or 144 cubic inches.

Boreal – (adj.) Of, relating to, or located in northern regions.

Broadleaf – (n) A tree with flat leaves that are not scaly or needlelike.

Cambium – (n) The layer of cells between the xylem layer and inner bark that function to create new growth in the tree.

Canopy – (n) The ceiling of a forest created by branches and leaves from several trees. Forests with dense canopies allow less sunlight to reach the ground than forests with open canopies.

Carotenoid – (n) Any of various usually yellow and red pigments found widely in plants and animals.

Catkin – (n) A cluster of tiny flowers or fruits, usually fuzzy and caterpillar shaped

Certification – (n) A process in which independent, qualified inspectors verify that land and forests are being managed sustainably. Wood and timber that are produced from these forests are labeled ***"certified."***

Chlorophyll – (n) The green photosynthetic pigment found in chloroplasts of plants and trees.

Chloroplast – (n) A plastid (cell) that contains chlorophyll and is the site of photosynthesis.

Climax community – (n) A relatively stable ecological stage or community especially of plants that is achieved through successful adaptation to an environment; especially the final stage in ecological succession.

Clone – (n) A sapling that is genetically the same as the parent tree. Saplings that sprout from stumps or roots (suckers) are clones.

Conifer – (n) A tree that bears its seeds in cones. ***Coniferous*** (adj.)

Consumer – (n) An organism that consume producers and other consumers.

Crown – (n) The top of the tree where the branches and leaves grow.

Deciduous – (adj.) A type of tree that sheds leaves annually in the fall.

Decomposer – (n) An organism that consumers producers and consumers, and produce (recycle) energy.

Decreaser – (n) A plant or animal that decreases in population when a habitat is stressed. For example, goblin ferns decrease when earthworms move into a forested area and consume the duff.

Dendrochronology (n) – The study of tree-ring patterns; annual variations in climatic conditions which produce differential growth can be used both as a measure of environmental change and as the basis for a chronology.

Dichotomous key – (n) A method for the identification of organisms based on a series of choices between alternative characters.

Dioecious – (adj.) Having staminate (male) or pistillate (female) flowers on different individuals

Duff – (n) The partly decayed matter on the forest floor.

Ecological Classification – (n) A system that identifies, describes, and maps units of land with different capabilities to support natural resources. This is done by integrating climatic, geologic, hydrologic, topographic, soil, and vegetation data.

Ecosystem – (n) The complex of a community of organisms and its environment functioning as an ecological unit.

Embryo – (n) A minute rudimentary plant contained within a seed.

Endosperm – (n) A nutritive tissue in seed plants formed within the embryo sac by division of the endosperm nucleus.

Esker – (n) String of long, low hills created as melting rivers of water beneath glaciers deposit soil.

Extracellular freezing – (n) A process in which liquids within cells seep out into the spaces between the cells, where they can freeze without harming plant tissue.

Forbs – (n) Herbaceous, flowering plants that are not graminoids (grasses, sedges, rushes).

Forest floor – (n) The layer in the forest that consists of soil and decomposers.

Generalist – (n) An organism that can thrive on unspecialized food or habitat. For example, raccoons are at home in both rural and urban areas because of their diverse diet and habitat requirements.

Germinate – (v) To sprout or develop.

Glacial erratic – (n) A rock and boulder of distant origin deposited by glaciers.

Glucose – (n) A simple sugar that is a major energy source for all cellular functions. Cells use it as a source of energy and metabolic intermediate. Glucose is one of the main products of photosynthesis.

Habitat – (n) The place or environment where a plant or animal naturally or normally lives and grows.

Hardening – (n) In plants, to become gradually acclimatized to unfavorable conditions.

Heartwood – (n) The inner layers of wood in growing trees that have ceased to contain living xylem cells. Heartwood is generally darker than sapwood, but the two are not always clearly differentiated. Also called ***inner wood.***

Herb layer – (n) The layer in the forest that consists of seedlings and nonwoody plants.

Humus – (n) A brown or black complex variable material resulting from partial decomposition of plant or animal matter and forming the organic portion of soil.

Increaser – (n) A plant or animal that increases in population when habitat is stressed. For example, ragweed increases as soil disturbance increases.

Inner bark – (n) The layer of live phloem cells growing just outside the cambium layer of living wood.

Inner wood – (n) The wood within the tree that is composed of aging sapwood or xylem. Inner wood gives structure and strength to the tree. Also called ***heartwood.***

Intermediate species – (n) The plants and animals being or occurring at the middle place or stage in an ecological cycle.

Invasive – (adj) An invasive tree spreads prolifically. A tree that does not spread prolifically is ***noninvasive.***

Kame – (n) A hill that formed as rivers of meltwater shot water and rocks off the edge of a glacier, depositing piles of soil as if a giant dump truck tipped out its contents all in one spot.

Kettle lake – (n) Lakes that formed as giant chunks of glacial ice rested on the land to melt, form depressions in the soil, and fill with groundwater. Also called ***pothole.***

Layering – (v) The process of sprouting a new seedling from live tree branches that come in contact with the soil.

Loam – (n) Soil consisting of a crumbling mixture of varying proportions of clay, silt, and sand.

Mesic – (adj.) Characterized by, relating to, or requiring a moderate amount of moisture

Monoecious – (adj.) Having staminate (male) or pistillate (female) flowers on the same plant.

Moraine – (n) An accumulation of earth and stones carried and finally deposited by a glacier. ***Lateral moraines*** form along the side of a glacier; ***terminal*** (or "end") ***moraines*** form at the end of a glacier when it stops growing, pauses, and then retreats. ***Ground moraines*** are piles of rock dropped along the general path of the glacier.

Native – (adj.) Originating in a particular place or in the vicinity. Trees originating from a distant place are called ***nonnative.***

Native plant community – (n) A natural association of plants dominated by one or more prominent native plant species growing in its natural habitat.

Natural Heritage Information System – (n) A system that provides information on Minnesota's rare plants, animals, native plant communities, and other rare features. The NHIS is continually updated as new information becomes available, and is the most complete source of data on Minnesota's rare or otherwise significant species, native plant communities, and other natural features. www.dnr.state.mn.us/eco/nhnrp.

Noninvasive – (adj.) A noninvasive tree does not spread prolifically. A tree that spreads prolifically is ***invasive.***

Nonnative – (adj.) Originating in a different region and acclimated to a new environment.

Old growth – (n) A forest characterized by the presence of large old trees, numerous snags and woody debris, and a multilayered canopy and that is usually in a late stage of ecological succession.

Oriented strand board (OSB) – (n) Building material composed of rectangular-shaped wood strands arranged in layers at right angles to one another, laid up into mats that form a panel, and bonded with waterproof adhesives.

Outer bark – (n) The layer of dead outer phloem cells that protect inner tissues from disease and drying.

Ovule – (n) The structure within the ovary that will become the seed after fertilization.

Phloem – (n) The layer of wood directly under the bark of the tree that transports sugars and water up and down the tree. Also called ***inner bark.***

Photosynthesis – (v) The process by which plants create energy and sugar from sunlight, water and carbon dioxide.

Pioneer species – (n) The plants or animals capable of establishing in a bare, barren, or open area and initiating an ecological cycle.

Pistillate – (adj.) The part of the flower that contains female portions of flowers, or the pistils.

Plumule – (n) The shoot that rises out of a sprouting seed toward the sun.

Pothole – (n) Lakes that formed when giant chunks of glacial ice rested on the land to melt, form depressions in the soil, and fill with melting water. Also called ***kettle lake.***

Prescribed burn – (n) The controlled application of fire to naturally occurring vegetative fuels, under specified environmental conditions and following appropriate precautionary measures, to achieve specific objectives, such as controlling brush, producing high quality browse, or reducing fuel hazards.

Producer – (n) An organism that produces energy from sunlight.

Province – (n) A major ecological community type (as tropical rain forest, grassland, or desert). Also called a ***biome.***

Radicle – (n) The shoot that extends out of a sprouting seed toward the ground.

Renewable resource – (adj) A resource that can be regenerated or re-grown by natural ecological cycles or sound management practices.

Respire – (v) To take up oxygen and produce carbon dioxide through oxidation.

Root – (n) The usually underground organ that lacks buds or leaves or nodes; absorbs water and mineral salts; usually it anchors the plant to the soil.

Sapling – (n) A young tree not more than 4 inches in diameter at breast height.

Sapwood – (n) The live layers of secondary xylem cells in older woody plants; visible as the outer lighter areas in the cross section of a tree trunk. Sapwood is usually lighter in color than the heartwood.

Savanna – (n) A temperate grassland with scattered trees (as oaks).

Seedling – (n) A young plant grown from a seed.

Serotinous – (adj.) Remaining closed on the tree with seed dissemination delayed or occurring gradually. For example, the cones of jack pine are serotinous.

Shade tolerance – (adj.) In plants, the level of tolerance to shade a species favors. Trees that thrive in shady areas are ***shade-tolerant.*** Trees that thrive in sunny areas are ***shade-intolerant.*** Trees that thrive in either condition are ***intermediately shade-tolerant.***

Shelterbelt – (n) A barrier of trees and shrubs that protects (as crops) from wind and storm and lessens erosion.

Shrub layer – (n) A layer in the forest that consists of saplings and smaller woody plants.

Slash – (n) An open tract in a forest strewn with debris (as from logging) or the debris in such a tract.

Specialist – (n) An organism specialized especially for a food or habitat. For example, pileated woodpeckers are specialists because they require habitat that consists of undisturbed forests with standing dead trees.

Spring wood – (n) The wood created by xylem cells in the spring. Trees create the most xylem in spring, resulting in a layer of xylem that is thicker and lighter in color than other rings.

Staminate – (adj.) Having or producing stamens, that is, the pollen-producing male organ of a flower that consists of an anther and a filament.

Stoma – (n) One of the minute openings in the surface of a leaf or stem through which gaseous interchange takes place. The plural of stoma is ***stomata.***

Stump sprouting – (v) The process of sprouting a new young tree from the stump of a tree.

Succession – (v) The unidirectional change in the composition of an ecosystem as the available competing organisms and plants respond to and modify the environment. Succession is part of the ecological cycle.

Suckering – (v) The process of sprouting a new young tree, called a sucker, from the root of another tree. The new tree that grows from the roots of another tree is called a ***sucker*** (n).

Summer wood – (n) The wood created by xylem cells in the summer. Trees create less xylem in the summer than in the spring, resulting in a layer of xylem that is thinner and darker in color than the other rings.

Supercooling – (v) To cool below the freezing point without solidification or crystallization.

System – (n.) A regularly interacting or interdependent group of items forming a unified whole.

Taproot – (n) The central root of a tree. Not all trees have a taproot.

Timber – (n) Wood other than fuelwood, potentially usable for lumber.

Timberland – (n) Wooded land especially with marketable timber.

Tree – (n) A woody plant that is 15 feet or taller at maturity, with a distinct branched-out area at the top, and usually a single stem.

Trunk – (n) The main stem of a tree.

Windbreak – (n) A growth of trees or shrubs serving to break the force of wind.

Understory – The vegetative layer of trees and shrubs between the forest canopy and the ground cover.

Xylem – (n) The cells that create wood. Xylem transports water and sugar from the leaves to the roots and vice versa. Trees put on a layer of xylem each year. People count the rings of xylem to determine a tree's age. Also called ***sapwood.***

INDEX

TREE QUOTES

All I Need to Know About Life, I Learned from Trees

It's important to have roots!

In today's complex world, it pays to branch out.

Sometimes you have to shed your old bark in order to grow.

Grow where you're planted.

Be flexible so you don't break when harsh winds blow.

It's perfectly okay to be a late bloomer.

Avoid people who try to cut you down.

Keep your temper when the sap starts to rise.

Get off your duff and get tough!

It's more important to be honest than 'poplar.'

Go out on a limb.

And that's our stump speech for today.