Chapter 6:

Managing Important Forest Types

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Foresters and scientists have developed several methods for classifying woodlands. These classifications help describe tree species that are currently present, or the combination of vegetation that would naturally occur on the site if it were undisturbed for a long period of time, or the site quality for growing particular tree species.

The "forest type" classification is based on the predominant tree species over an area of woodland. Forest types are named for one to three tree species that comprise at least 20 percent of the basal area in a mature stand or a predominance of stems in seedling and sapling stands. Forest type classification has been standardized across the United States, but each forest type has many variants. A forest type designation recognizes the combination of tree species currently in a woodland, but that type may not be the best type to grow on the site where it exists. We use forest types in this book because they are relatively easy for landowners and foresters to recognize and you do need to base management decisions on what tree species are present, even if you're trying to move the stand toward another combination of tree species that is better suited to the site.

A "plant community" classification considers site factors in designating the trees and other plants most likely to occupy a site if it were undisturbed for a long period of time.

A "vegetative habitat type" (also known as "site type" or "native plant community") classification identifies forest sites along a soil moisture-nutrient gradient. It takes into consideration soil texture, fertility, and moisture and leads to designation of tree species best suited to each site type. Site types are recognized by characteristic understory plants rather than tree species.

An "ecological classification" system is based on climate, geology, landforms, landscape position, soil and vegetation. This hierarchical system first defines large large-scale ecosystems that are multistate in scope (a province), then subdivides those ecosystems into smaller and smaller parts, down to a few acres (ecological land type phase) as the criteria are refined.

This chapter describes management of important forest types in the Lake States—Minnesota, Wisconsin, and Michigan. These descriptions are brief and may not provide adequate information for managing specific stands because so many site types and species combinations exist. A forester should inspect your woodland and prepare stand management plans before you implement any forestry practices.

Range maps help you determine what tree species are likely to be found in your area. A species usually grows better and its wood has greater commercial potential in the heart of its range, as opposed to the edge of its range where environmental factors may limit its growth.

Site index curves help you determine whether the growth potential on your land is high or low for a species. To determine the site index for a species on a particular site, you need to know the average age and total tree height for trees of that species on the site, then refer to site index curves such as those found in the appendixes of this book.

Aspen

The aspen forest type, dominated by quaking aspen (also called "poplar" or "popple") and bigtooth aspen, covers more area than any other forest type in the Lake States (Figure 6-1). Paper birch and pin cherry are common associates. Balsam poplar (balm of gilead) is found on moist sites. Aspen is very intolerant of shade and relatively short-lived.

Figure 6-1. Range of quaking aspen.

Stands can be invaded readily by more shade-tolerant species. On dry sites, aspen may be replaced by red pine, red maple, or oaks; on sites with intermediate moisture, by white pine; on fertile sites by northern hardwoods, white spruce, and balsam fir; and on the wettest sites by balsam fir, black spruce, black ash, and northern white-cedar.

Products and Uses

Aspen species are used principally for paper and particleboard, but also for lumber, studs, veneer, plywood, shingles, matches, novelty items, biomass fuel, and animal feed. Aspen stands are important habitat for ruffed grouse, woodcock, snowshoe hare, beaver, porcupine, white-tailed deer, moose, and black bear.

Site Conditions

Aspen grows on a wide range of soils from shallow and rocky to deep loamy sands and heavy clay. Good soils are well-drained, loamy, and high in organic matter, calcium, magnesium, potassium, and nitrogen. The best sites have soils with silt-plus-clay content of 80 percent or more. Aspen prefers a water table from 2 to 8.2 feet deep. It grows poorly on sandy or droughty soils and on heavy clay.

Site index commonly is used to evaluate site productivity when aspen stands are at least 20 years old and have not been damaged by fire or overtopped by other species (Appendix B-1: Site index curves for quaking aspen). Manage aspen for timber only where the site index is 60 or better.

Regeneration

Regeneration from seed is possible, but unreliable. Good seed crops occur every four to five years on 50- to 70-year-old trees. Seeds ripen in May to June and are dispersed long distances by wind and water. They require a water-saturated seedbed for germination. A moist, bare mineral soil is best.

Aspen stands most commonly regenerate from root suckers that grow from lateral roots after a stand has been harvested or killed by fire or wind. Because aspen is very intolerant of shade, optimum root suckering occurs when the stand is completely clearcut. Do not leave more than 20 mature trees an acre after harvesting. If logging does not destroy undesirable trees and shrubs, remove them by felling, girdling, basal spraying, or controlled burning. Root suckering is most prolific when:

- Clearcutting is done when the soil is relatively dry or frozen to avoid damaging the lateral roots within 4 inches of the soil surface that produce the suckers. This is especially important on clay soils with a high water table.
- Harvesting occurs during the dormant season when food reserves stored in the roots are at a maximum, especially on fine-textured soils.
- Soil temperature is 74˚ F. (High soil temperature inhibits suckering.)
- Parent trees are healthy and have high carbo hydrate reserves. Grazing, repeated cropping, killing of sucker stands, and insect defoliation will lower carbohydrate reserves.
- There is no excess soil moisture (to impede aeration) or severe drought.

If a stand is harvested during the growing season, root suckers will begin to grow immediately after trees are felled. Do not drive heavy equipment across young sprouts or they will be killed. To protect new sprouts begin logging at the rear of the stand, then progress toward the log landing.

Harvest stands for pulpwood at age 45 to 55 and for sawtimber at age 55 to 65. Harvest earlier if more than 30 percent of the trees are diseased (indicated by the presence of fungal conks or bark cankers).

Old, decadent stands with low vigor and stands with fewer than 50 mature aspen trees an acre may be difficult to regenerate. Encourage maximum suckering by harvesting these stands during the dormant season when the ground is frozen or relatively dry. If an old stand does not have a merchantable volume of wood, you may kill the old trees and stimulate suckering by felling the trees, by shearing them with a sharp blade on a bulldozer when the soil is frozen, or by setting a prescribed fire.

Two years after clearcutting there should be at least 5,000 aspen root suckers an acre. Some stands may have up to 30,000 root suckers an acre. The more the better, since aspen stands naturally thin themselves. If root sucker density following the clearcut appears low, ask a forester to judge whether the stand is adequately stocked. If stocking is not adequate, wait at least 10 years, then clearcut the stand again. Following this second clearcut, sucker density should improve to a satisfactory level.

Aspen will not compete well with other hardwoods such as maple, basswood, ash, and oak. Over time the aspen will die from disease and be replaced by more shade-tolerant species. Clearcutting a mixed species stand favors aspen regeneration. Removing aspen during thinning will favor other hardwood species.

Where you find mature aspen with an understory of white spruce and balsam fir (two shade-tolerant conifers), clearcutting aspen while damaging the conifers will reproduce mainly aspen. In contrast, carefully harvesting the aspen while leaving the conifers undamaged will enable aspen root suckers to survive in scattered patches. In 40 to 50 years the conifers and aspen will mature. Clearcutting then will regenerate a stand of mainly aspen with a few scattered conifers.

Intermediate Treatments

Once an aspen stand has regenerated, trees grow rapidly. A densely stocked stand thins naturally; artificial thinning is unnecessary to produce pulpwood and may increase losses from hypoxylon canker and rot. Dense stands also promote natural pruning. Artificially thinned stands may produce more sawtimber and veneer than unthinned stands, but thin to grow these products only when disease incidence is low and the site index is 70 or higher. One thinning at about age 30 leaving approximately 240 trees an acre may be appropriate. Row thinning of sapling stands has produced faster volume growth on residual trees, but results are inconsistent. Take great care to avoid wounding residual aspen trees, since decay and discoloration can enter trees through those wounds.

Pests and Diseases

Aspen is highly susceptible to fire damage. Major insect pests are forest tent caterpillar, large aspen tortrix, gypsy moth that feed on leaves, and various wood borers that weaken and degrade the stem. Several species of fungi cause stem cankers or white rot that reduce the volume of usable wood.

To reduce losses from these pests, do not grow aspen for timber where the site index is less than 60. Stands growing on poor sites are highly susceptible to pests. Try to regenerate 30,000 suckers an acre and maintain a high number of stems an acre to discourage poplar borer and hypoxylon canker. Do not thin aspen; wounds on residual trees will favor establishment of poplar borer and hypoxylon canker.

To minimize pest damage, harvest trees by age 40, unless the site index is at least 75 and veneer is the desired product. If fewer than 15 percent of the trees are infected with hypoxylon canker, stands may grow longer than 40 years. If 15 to 25 percent of the trees are infected with hypoxylon canker, harvest early and regenerate aspen. If more than 25 percent of the stand is infected, consider converting to an alternate forest type or species. Harvest early if white rot affects more than 30 percent of the basal area.

Repeated defoliation by forest tent caterpillar will weaken the trees, increasing their susceptibility to disease. Insecticides may be required to protect the stand during prolonged outbreaks.

Balsam Fir

The balsam fir type occurs across the northern Lake States (Figure 6-2). Common associates include black spruce, white spruce, paper birch, quaking aspen, bigtooth aspen, yellow birch, American beech, red maple, sugar maple, eastern hemlock, eastern white pine, tamarack, black ash, and northern white-cedar.

Figure 6-2. Range of balsam fir.

Products and Uses

Balsam fir is used mainly for pulpwood and small sawtimber. Wood waste is burned for energy. Fir stands provide summer shade for moose, deer, and bear and winter cover for moose and deer. Timber wolves, pine marten, fisher, lynx, and bobcat are associated with this type of woodland. Hares, spruce grouse, and songbirds use these stands for cover and a food source. Balsam fir boughs are extensively clipped for wreaths and small trees are cut for Christmas trees.

Site Conditions

Balsam fir grows on a wide range of inorganic and organic soils and on wet to dry sites. It is most common on wet to moist sites, where soil moisture is adequate throughout the growing season and standing water may be present during part of the season. On moist sites balsam fir is gradually replaced by northern hardwoods such as sugar maple. On wet sites it usually is dominated by black spruce and tamarack. Good sites are found on well-drained loams and moderately well-drained silt loams, clay loams, and clays. It grows where pH is 5.1 to 6.0, but does best with pH 6.5 to 7.0 in the upper organic layers. A site index (Table 6-1) is most reliable when measuring dominant balsam firs that have not been previously suppressed in even-aged stands or by assessing the site index of associated species (Appendix B-2: Site index curves for balsam fir in the Lake States). The balsam fir site index is unreliable in uneven-aged stands.

Table 6-1. Comparative site index for balsam fir and common associates.

Balsam fir	Quaking aspen	Paper birch	Black spruce	Northern white-cedar
Site index in feet				
60	70	70	60	40
50	60	55	50	35
40	50	40	40	30
30	35	25	30	25

Source: Johnston, W. F. 1986. Manager's handbook for balsam fir in the north central states. General Technical Report NC-111. USDA Forest Service, North Central Forest Experiment Station. P. 5.

Regeneration

Beginning at age 30, balsam fir produces good seed crops every two to four years. Wind disperses seed for 80 to 200 feet from mature trees. If enough moisture is available, seeds will germinate on almost any seedbed and seedlings will survive for several years with only 10 percent of full sunlight. The best seedbed is medium-textured mineral soil with some shade. Thick duff with no shade is a poor seedbed. Scarification that incorporates duff will improve the seedbed.

Because balsam fir is very shade tolerant, it can be managed in uneven-aged stands, especially on moist-wet sites. Use a two-stage shelterwood harvest, leaving 60 percent crown cover where advance regeneration is not adequate and where residual firs are known to be windfirm (resistant to strong winds).

Balsam fir also can be managed in even-aged stands by clearcutting in alternate or progressive strips or patches. Use clearcutting where the shelterwood system will lead to excessive mortality from rot, wind, or spruce budworm or where advance regeneration of fir is well established before the cut. Cut strips perpendicular to, and progressing toward, the prevailing wind. Cut strips up to three chains wide with seeding from both sides or

two chains wide with seeding only from the windward side.

Excessive slash from harvesting will hinder growth of advance regeneration and provide too much shade over a seedbed. Reduce slash by full-tree skidding.

Balsam fir is seldom planted because of low market demand and the relative ease of regeneration by natural seeding.

Depending on site conditions and the tree species mix that is present, a balsam fir stand can be converted to other forest types. In a mature stand of fir with some aspen, clearcut to produce a stand of aspen suckers with scattered firs. If advance fir regeneration is sparse, place harvest areas within two to three chains of seed-bearing firs. Firs will grow up with the aspen. Once the aspen has matured, cut the aspen, being careful to preserve the firs for longer growth. Some aspen will regenerate in the openings, sustaining a two-species stand. When the firs mature, repeat the cycle by clearcutting.

Where balsam fir forms an understory beneath paper birch, clearcut the birch to release the fir. To reduce spruce budworm problems, maintain some overstory birch by clearcutting progressive strips or small patches. To ensure a birch component in the new stand, scarify the soil in scattered openings and leave seed-bearing birches within three chains.

In a balsam fir stand with at least three to five paper birch seed trees an acre, you can retain a birch component by clearcutting the stand in progressive strips or small patches or using shelterwood cutting. Cut strips one to two chains wide and patches one acre or less. Scarify about 50 percent of the harvest area to prepare seedbeds for fir and birch. Whole-tree skidding when the soil is not frozen or snow covered will scarify the site. About eight years after the harvest, thin the new stand to manage the mix of fir and birch.

In northern hardwood stands with a balsam fir component where the site index for sugar maple is greater than 55, control fir advance regeneration to favor hardwood reproduction and clearcut mature fir if hardwood advance reproduction is adequate. Adequate stocking is 5,000 hardwood seedlings three to four feet tall or 1,000 saplings two to four inches DBH. If hardwood reproduction is not adequate, remove the firs in two or more shelterwood harvests to favor hardwoods.

On less well-drained hardwood sites (with a sugar maple site index of less than 55) manage balsam fir along with other hardwoods. These include yellow birch (plus eastern hemlock in Michigan and Wisconsin) on somewhat poorly drained sites and black ash and red maple on poorly drained sites. To grow only pulpwood, clearcut where fir advance growth is adequately stocked and use shelterwood harvest where it is not. To grow both pulpwood and sawlogs, thin young stands to obtain the desired mix of fir and hardwoods. Then harvest the fir at about age 50 and leave the hardwoods until they mature (at roughly age 100). When the hardwoods are mature, reproduce all species as described above. Selection cutting is suitable where a high proportion of fir is desired.

Where balsam fir occurs with pine on dry to moist-dry sites (usually sandy soils), encourage red pine (or jack pine on very dry sites) by eliminating all fir when harvesting pines.

Balsam fir often forms an understory in mature white pine stands on moist to moist-wet sites. This understory may improve wildlife habitat or esthetics, but for timber production the fir should be removed to facilitate regeneration of white pine or other conifers.

On moist to moist-wet sites where balsam fir is mixed with white spruce, spruce is preferred because of its higher timber value, longer life, and greater tolerance to spruce budworm defoliation. If a mature fir stand has more than 500 well-distributed white spruce that are three feet or taller an acre, clearcut the stand to release the spruce, but take care to minimize logging damage. If spruce regeneration is not adequate, either use shelterwood cutting and scarification to encourage spruce or clearcut the stand and plant white spruce. As the new stand grows, weed out balsam fir during thinnings.

On moist-wet to wet sites where balsam fir is mixed with northern white-cedar and black spruce, minimize the fir component. Broadcast burn harvest sites to eliminate woody debris and undesirable small trees and shrubs to create a good seedbed for white-cedar and spruce.

Intermediate Treatments

The degree to which competing vegetation should be controlled depends on the management objective and type of site. Mixed species stands enhance wildlife habitat and aesthetics and reduce the potential for spruce budworm damage. On wet and moist-wet sites, balsam fir will eventually grow above associated hardwoods, but on moist sites with northern hardwoods, balsam fir will be suppressed. Balsam fir responds well to release when trees are still young and vigorous (for example, with current annual height growth of six inches or more, a fairly pointed crown, and smooth bark with raised resin blisters). A single herbicide release or cleaning about eight years after a harvest or when stand height averages 6 to 10 feet will help ensure balsam fir dominance.

Desirable balsam fir stand densities are not known for optimum timber growth in the Lake States, but a stocking chart for even-aged spruce-fir stands from the Northeast offers some guidance (Appendix C-1: Stocking chart for even-aged spruce-balsam fir stands).

Pests and Diseases

The spruce budworm is the major insect pest of balsam fir. Budworm survives best on older trees and in dense stands. To minimize damage, manage fir on a 40- to 50-year rotation, keep large forest areas well diversified by age class, thin stands to maintain vigorous growth, and maintain a high spruce and hardwood component. Insecticide use may be warranted in high value stands that have been defoliated for two consecutive years and that cannot be harvested within five years.

Heart rot and root rot are major diseases. To minimize damage follow budworm management practices to sustain vigorous stands and avoid scarring trees during intermediate cuttings.

Windthrow—trees uprooted or broken by wind—can be a serious condition, especially on wet, shallow soils. Minimize windthrow by maintaining a well-stocked, vigorous stand. Do thinning and shelterwood cutting only on sites where fir is known to be windfirm. When making a partial cut, ensure the windward side is protected by a zone of uncut timber at least one chain wide and make cutting boundaries straight. In mixed stands with hardwoods, maintain a well-distributed hardwood component. If damage becomes severe, conduct a salvage harvest.

Birch

Paper birch forms either small pure stands or mixtures. Quaking and bigtooth aspen and pin cherry are its most common associates. It also may be mixed with yellow birch, red maple, northern red oak, white pine, jack pine, white spruce, and balsam fir. This forest type occurs throughout the northern Lake States (Figure 6-3).

Figure 6-3. Range of paper birch.

Products and Uses

The main uses for paper birch are paper, fuelwood, dowels, and novelty items, but it also is used for lumber and veneer. Birch trees can be tapped in the spring to obtain sap for syrup, wine, beer, or medicinal tonics. Its showy white bark and bright yellow fall foliage make it an attractive landscape

tree. Young stands provide an important source of browse for deer and moose. Songbirds feed on its seeds while ruffed grouse and squirrels eat male buds and catkins.

Site Conditions

Paper birch is a pioneer tree type that revegetates land disturbed by fire, clearcutting, and other factors. It grows on almost any soil and topographic situation, ranging from steep, rocky outcrops to flat muskegs or bogs. Paper birch tends to grow best on deep, well-drained to moderately well-drained, nutrient rich glacial deposits. It grows poorly on very dry and very wet sites.

Regeneration

Paper birch is intolerant of shade and usually is regenerated by clearcutting or shelterwood systems. Although small birches produce vigorous stump sprouts when cut, merchantable-size trees do not sprout well and sprouts are normally of low quality. Natural seeding is the most common source of regeneration. The optimum seedbearing age is 40 to 70 years. In mature stands, good seed crops occur every other year on the average, but some seeds are produced in most areas every year. Its light seeds are dispersed readily by the wind; however, the majority of seeds fall within the stand where they are produced. If a clearcut has to be more than 300 feet wide, leave seed trees throughout the site to get adequate seed dispersal and provide for the survival of seed trees and protection of new seedlings. Remove seed trees within two years after acceptable regeneration.

Paper birch germinate best on mineral soil, so site preparation by disking or burning is recommended. Germination on humus is reduced by about 50 percent, but initial height growth is better on humus than on undisturbed sites, probably because of greater nutrient availability. Germination on undisturbed litter is relatively poor.

Shaded sites produce about twice as many seedlings as full-sun sites, so harvest by narrow, progressive clearcut strips, small patch clearcuts, or a two-cut shelterwood system (especially on hot, dry sites). In a shelterwood system, the first cut should thin the canopy and provide more sunlight to the forest floor. A year later, disk the site to lightly bury the birch seeds, help control competing vegetation, and incorporate organic matter. Disking is especially helpful following a good seed fall. After the stand is sufficiently stocked with seedlings, canopy trees should be clearcut to release the new seedlings.

To establish birch on old field sites, remove the sod, plant bare-root or container-grown seedlings, and protect them from girdling by rodents and browsing by deer.

Intermediate Treatments

Young paper birch grows rapidly, but the growth rate declines significantly in old age. The species is short-lived, reaching maturity in 60 to 70 years. It usually lasts only one generation and then is replaced by more shade-tolerant species. Poor sites may be clearcut for firewood every 40 years or converted to another species. Good sites can be managed for sawlogs on 50-year or longer rotations. On good sites that are clearcut and regenerate to aspen, pin cherry, and paper birch, the faster growing aspen and pin cherry will outgrow and suppress the birch.

Birch often grows in two-story stands. When paper birch has an understory of white spruce or balsam fir, the conifers will eventually dominate the stand, but birch will retain a presence. When paper birch has an understory of northern hardwoods (such as, sugar maple, red maple, basswood, ash, and some oaks), the birch will be replaced by the hardwoods over time. To retain a higher percentage of birch, thin mixed species stands to release the birch. Gradual thinning over time is recommended. The more intense the thinning (the more trees removed), the greater the height and diameter growth response of paper birch. However, heavily thinning a stand that has not previously been thinned may cause many of the remaining trees to die. Stands approaching maturity seldom respond well to thinning.

Pests and Diseases

Bronze birch borer is the most serious insect pest of paper birch. Usually it attacks overmature trees or weakened trees. The most serious defoliators are the forest tent caterpillar, birch skeletonizer, birch leafminer, birch leaf-mining sawflies, birch casebearer, and gypsy moth. Defoliation alone seldom kills healthy trees, but it reduces their growth rate and makes birch susceptible to other damaging agents, particularly bronze birch borer.

Birch also is affected by decay-causing fungi, stem cankers that ruin the tree for timber purposes, and root-rotting fungus.

Over-browsing by deer and moose at the seedling stage reduces the amount of dominant birch in regenerating stands or impairs the quality of survivors. Porcupines damage larger trees by feeding on the inner bark and girdling large branches in the crown and upper trunk. The yellow-bellied sapsucker pecks rows of holes through the bark; these become the point of entry for decay organisms and ring shake (separation). Hares and other small mammals may seriously damage planted seedlings.

Because paper birch bark is thin and highly flammable, even large trees may be killed by moderate fires.

Paper birch is very susceptible to logging damage during partial harvest treatments using mechanical techniques.

Black Ash–American Elm–Red Maple

This type of woodland occurs throughout the Lake States (Figure 6-4) with varying proportions of ash, elm, and maple. American elm has declined in importance because of the prevalence of Dutch elm disease. The most common associates are balsam poplar, balsam fir, and yellow birch, but also may include eastern white pine, tamarack, black spruce, northern white-cedar, white spruce, quaking aspen, slippery elm, paper birch, and American basswood. Management recommendations in this section focus on black ash.

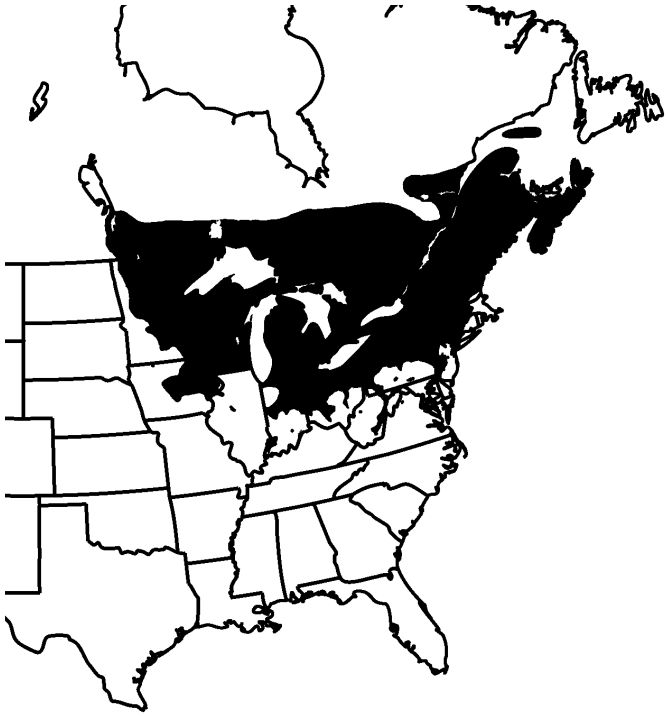

Figure 6-4. Range of black ash.

Products and Uses

Black ash is used for lumber, veneer, fuelwood, and baskets. The need for more basket-grade trees has resulted in greater interest in managing black ash, especially around Native American communities. Its seeds are an important food to game birds, songbirds, and small animals, and the twigs and leaves provide browse for deer and moose.

Site Conditions

Black ash typically grows in bogs, along streams, and in poorly drained areas that often are seasonally flooded. It is most common on peat and muck soils, but also grows on fine sands that are underlain by sandy till (mixed clay, sand, gravel, and boulders) or on sands and loams that are underlain by clayey till. It can tolerate semi-stagnant conditions, but for best growth, the water should be moving so the soil will be aerated even though saturated. It tolerates pH from 4.4 to 8.2. In the northern Lake States the type frequently grades into northern white-cedar on wetter sites and into hemlock-yellow birch on better-drained areas. In northern Wisconsin it grades into tamarack or black spruce stands.

Regeneration

Black ash reproduces from stump sprouts when trees are less than 12 inches DBH, from root suckers after trees are cut, and from seeds. It produces good seed crops about every four years. Because of seed dormancy requiring cold treatment, black ash seed does not normally germinate under natural conditions until the second year, and seed may remain viable for eight years.

Regenerate stands that are 15 to 18 inches DBH or 110 to 130 years old. A partial or complete removal of the overstory without advance regeneration will allow a rise in the water table, leading to a lack of seedling regeneration and stump sprouting.

If there are fewer than 5,000 desirable seedlings an acre, make a shelterwood cut, leaving 75 percent crown cover of the best quality trees. When stocking reaches 5,000 seedlings an acre, reduce the crown cover to 50 percent. When seedlings are 2 to 3 feet tall (at about three to five years), clearcut the remaining trees when the ground is frozen and preferably covered with at least a foot of snow to reduce damage to seedlings.

To reinforce natural regeneration, plant 1-0 or 2-0 seedlings. (e.g. 1 or 2 year old seedlings).

Intermediate Treatments

Black ash is a small, slow growing tree, commonly reaching just 8 to 10 inches DBH when mature. It is intolerant of shade.

In pole-sized stands, release crop trees about 5 feet beyond their crowns. Delay later thinnings until the crowns close and the lower branches have self-pruned, then thin to 90 percent crown cover. During thinnings, remove undesirable species and trees with poor stem form, suppressed crowns, or signs of disease or damage.

Pests and Diseases

Trunk rot and butt rot are the most serious diseases affecting black ash. Emerald ash borer is an invasive insect species that infests and kills all species of ash. It occurs in parts of Michigan, Minnesota, and Wisconsin and is moving westward. Contact your state forestry agency for recommendations if your ash trees are dying or if you suspect they may be infested with emerald ash borer. Do not import or export firewood beyond the local area to minimize insect movement in the wood. Deer browse heavily on young black ash and if poplars are scarce, beaver will cut down ash.

Black Spruce

Black spruce commonly grows in pure stands on organic soils and in mixed stands on mineral soils. Mixed stands often include northern white-cedar, white spruce, balsam fir, and tamarack. It is found throughout the northern Lake States, but especially northern Minnesota (Figure 6-5).

Figure 6-5. Range of black spruce.

Products and Uses

Black spruce is grown almost exclusively for pulpwood. The spruce grouse depends on this forest type for most of its food and cover. Several songbirds use this forest type in summer.

Site Conditions

Black spruce usually grows on wet organic soils, but productive stands are found on a variety of

soil types from deep humus through clays, loams, sands, coarse till, boulder pavements, and shallow soil over bedrock. The most productive black spruce stands are on dark brown to blackish peats, which usually have a considerable amount of decayed woody material. The best sites occur where the soil water is part of the regional groundwater system and is enriched by nutrients flowing from mineral soil areas. The poorest sites occur where the soil water is separated from the groundwater system, and where there is two feet or more of poorly decomposed, yellowish-brown sphagnum moss. When found on mineral soil, black spruce grows best where the slope is gentle and moisture is plentiful, either from a shallow water table or seepage along bedrock. Site index curves for black spruce are in Appendix B-3 on page 201.

Regeneration

Rotation lengths for black spruce range from 60 to 140 years, but usually should not exceed 100 years on organic soils or 70 years on mineral soils because of butt rot and subsequent wind damage.

Black spruce stands 40 years or older have a nearly continuous seed supply. Good seed crops occur every two to six years, but partially closed cones remain on trees and disperse seed over several years. Under natural conditions, most seed is dispersed after a fire. Reproduction by layering (root development from low-hanging branches) is common in swamps and bogs.

A good seedbed is moist, but not saturated, and free from competing vegetation. Moist mineral soil usually provides a good seedbed, but exposed mineral soil may be too waterlogged or subject to frost heaving in low-lying areas. Living sphagnum moss makes a good seedbed, but some moss species may outgrow and smother spruce seedlings. Other mosses, especially feather mosses, tend to dry out after clearcutting and make poor seedbeds. Moss seedbeds should be removed by fire or machine or compacted by machine.

Clearcutting blocks or strips is the best method for harvesting and reproducing black spruce.

The best growing sites on organic soil usually are brushy and require broadcast burning of slash to reduce shrub competition. To avoid heavy slash that covers desirable residual trees or good sphagnum moss seedbeds, use whole-tree harvesting or burn the slash. Fires that completely remove the surface organic layer usually provide good seedbeds. Seedbed scarification also increases the number of surviving black ash seedlings.

Natural seeding can be effective with large, windfirm stands. Cut progressive strips perpendicular to the prevailing wind to maximize seed dispersal and minimize wind damage. Cut these strips into the wind, up to six chains wide where natural seeding occurs from both sides, or four chains wide where natural seeding occurs only from the windward side.

Rely on natural seeding along the outer portion of large stands while considering direct seeding of interior areas. On well-prepared sites, sow two to three ounces of seed an acre between March and mid-May of the first year following burning or other site preparation. Treat seed with bird repellent and fungicide.

Natural seeding, especially on nonbrushy sites, often results in stands that are too dense for optimum pulpwood growth. To avoid overstocking, count the trees three years after site preparation. If there are at least 600 healthy, well-spaced black spruce seedlings an acre that are at least 6 inches tall, clearcut the adjacent area of mature spruce to eliminate further seeding into the new stand.

Planting seedlings is more reliable than seeding, but also more expensive. Black spruce can be planted successfully using 3-0 or container-grown seedlings. Transplants (2-2) are expensive but useful where serious weed competition is expected.

Intermediate Treatments

Thinning overstocked sapling and poletimber stands is generally not economical and may lead to increased wind damage. Although black spruce is shade tolerant, on good sites a dense overstory of undesirable shrubs or hardwoods may severely

suppress seedling growth. In these situations control brush with herbicide to release the spruce.

Pests and Diseases

Eastern dwarf-mistletoe is the most serious disease affecting black spruce. It causes branch deformations (witches' brooms, or dense clusters of abnormal small branches), reduces growth, and eventually kills trees. Mistletoe survives only on living trees and spreads slowly. To kill mistletoe, cut all trees in infected areas plus a border strip one to two chains wide; then burn the site with a hot fire. To prevent mistletoe infections, clearcut and burn all mature stands where feasible to eliminate undetected mistletoe sources.

Wind may cause substantial breakage and uprooting in older black spruce stands, especially where butt rot is present and where stands have been opened up by partial cutting. Minimize wind damage by using the rotations recommended above and clearcutting narrow strips that progress over time toward prevailing winds.

Black Walnut

Black walnut (Figure 6-6) generally is found scattered among other tree species. Pure stands are not common, but do occur. Common associates include yellow-poplar, white ash, black cherry, basswood, beech, sugar maple, oaks, and hickories. Its leaves and roots actively secrete material toxic to some trees, shrubs, and herbaceous plants.

Products and Uses

Wood products from black walnut include sawlogs, veneer logs, gun stocks, and smaller novelty pieces. Nuts are excellent for human consumption. Frequent nut crops make it an excellent tree for wildlife, especially squirrels. Nut shells are used as an abrasive in grinding and polishing.

Site Conditions

Walnut grows best on lower north- and east-facing slopes, stream terraces, and floodplains. It is common on limestone soils and grows well on deep loams, loess soils, and alluvial deposits that are fertile and moist, but well-drained. Poor sites for walnut include steep south- and west-facing slopes, narrow ridgetops, and poorly drained sites. Soils with acid clayey subsoils, coarse sand or gravel layers, or bedrock within 2.5 feet of the surface are not suitable for walnut. Site index curves for black walnut plantations are in Appendix B-4.

Figure 6-6. Range of black walnut.

Regeneration

The rotation length for black walnut is 50 to 80 years. It naturally regenerates from seed and stump sprouts if trees are less than 20 to 30 years old. Since black walnut trees normally are a minor component of a woodland, natural regeneration is unreliable and planting seedlings is recommended.

Black walnut is intolerant of shade. To prepare a woodland site for planting, cut or kill with herbicides all woody vegetation larger than 0.5-inches in diameter. On grassy and weedy sites apply herbicides in the year before planting to kill existing vegetation in planting strips or blocks. Plant seedlings at a spacing of 10 by 10 feet for timber production and 15 by 15 feet for a combination of timber and nuts. In field plantings for timber, planting a conifer (such as white or red pine) in

every third row may increase the survival rate, growth rate, and improve the stem form of walnut trees. Plant seedlings in the spring as soon after the ground thaws as possible. Use seedlings at least 1/4-inch in diameter, measured 1-inch above the root collar.

Seeds are easier and less expensive to plant than seedlings, but must be protected from squirrels and other rodents. Mechanical barriers (such as hardware cloth and tin cans) are most reliable, but they are expensive and time consuming to install.

Sow seeds in either fall or spring. Husks do not need to be removed for fall planting. Spring planting eliminates overwinter feeding by rodents, but requires that the seed be stratified before planting to break dormancy. (Stratification involves subjecting seed to cold temperatures and regulating moisture usually for a couple of months but variable by species.)

Intermediate Treatments

Control weeds for at least three years after planting to maximize the sunlight, moisture, and minerals available to walnut seedlings and to reduce plant cover that encourages rodents. Control weeds by mowing or cultivation in open field plantings or by herbicides. In most situations herbicides are more cost effective and reliable than mowing or cultivation.

Corrective pruning can improve seedling form if tip dieback or stem forking has occurred. Do not prune too heavily; young stems have a strong natural tendency to grow upright. Clear-stem pruning is recommended to help produce knot-free wood.

Fertilization generally is not needed on a good black walnut site unless a specific nutrient is deficient. Foliage analysis will reveal any nutrient deficiencies. Weeds are the usual benefactors of fertilizers.

Thin the stand lightly and frequently, perhaps every 10 years, to maintain rapid, uniform growth. If you planted conifers along with the walnuts, remove the conifers when they compete for crown space. When thinning, provide at least 5 feet of space around three-quarters of the crowns of crop trees. Select crop trees early by choosing those with straight stems, one dominant leader, well-formed crowns, and no apparent signs of disease or injury. Kill competing trees by felling or girdling and treating them with an herbicide.

Pests and Diseases

The major pests of black walnut are walnut caterpillars and bud borers. Pesticides usually are not economical. The major diseases that infect black walnut are anthracnose and fusarium canker. Fungicides may be necessary to control anthracnose for the purpose of improving nut production, and insecticides may be necessary to control caterpillars. Anthracnose can be managed by controlling weeds that weaken the trees. Fusarium canker can be controlled by restricting pruning to late winter. Fire is highly damaging to black walnut.

Incorrect pruning can lead to serious problems, including fusarium canker, bark necrosis, and sunscald.

Bur Oak

The bur oak type occurs across Minnesota, Wisconsin, and southern Michigan (Figure 6-7). Because it tolerates a wide range of soil and moisture conditions, bur oak associates with many other trees. Northern pin oak and black oak are associates on sandy sites; white oak and hickories are found with it on other dry upland sites. Chinkapin oak and eastern red cedar are associates on hot, dry hillsides in southwestern Wisconsin. Associates on lowland sites include shagbark and other hickories, black walnut, eastern cottonwood, white ash, American elm, swamp white oak, American basswood, black ash, silver maple and sycamore. Because of its fire and drought resistance, bur oak is the most common tree on oak savannahs along the prairie-forest transition zone in Wisconsin and Minnesota.

Products and Uses

Bur oak wood is commercially valuable for sawlogs and veneer, although high quality timber is

not common. Their acorns are a prime food for squirrels, wood ducks, white-tailed deer, and small mammals.

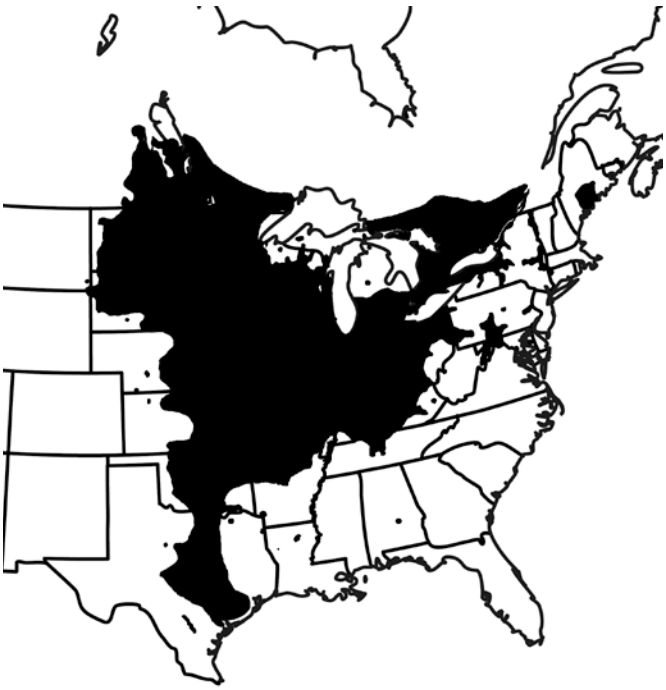

Figure 6-7. Range of bur oak.

Site Conditions

Bur oak is one of the most drought resistant North American oaks. On uplands it often is associated with soils of limestone or sandstone origin. It is found on droughty sandy plains, black prairie loams, and on loamy slopes of south and west exposure. Toward the western edge of its range, it is more abundant on moist north-facing slopes than on south-facing slopes. It often dominates severe sites with thin soils, heavy claypan soils, gravelly ridges, and coarse-textured loessial hills. Bur oak is also an important bottomland species throughout much of its range.

On the prairie edge it is a pioneer tree, commonly succeeded by northern pin oak, black oak, white oak, and bitternut hickory. On moist sites it is replaced by the more shade tolerant sugar maple, American basswood, and American beech.

As a bottom-land species, bur oak is relatively intolerant of flooding. First-year mortality may be 40 to 50 percent if seedlings are submerged for two weeks or more during the growing season. For shorter periods of growing-season submersion, seedling mortality is only 10 to 20 percent.

Regeneration

Bur oak is slow-growing, but commonly lives 200 to 300 years or longer. The minimum seed-bearing age is about 35 years and the optimum is 75 to 150 years. Good seed crops occur every two to three years. Acorns are disseminated by gravity, squirrels, and to a limited extent by water. Germination usually occurs soon after seedfall (August through November), but acorns from some northern trees may remain dormant through winter and germinate the following spring. Acorn germination and early seedling development is best on moist, mineral soil with no litter cover.

Bur oak stands are self-sustaining on dry sites, but planting seedlings and controlling grass and brush will aid regeneration. Bur oak will be difficult to sustain on moist bottomland sites where other species grow faster, but planting seedlings during regeneration phases will help sustain some bur oak in the species mix. Although mature bur oaks have thick, fire-resistant bark, it's important to prevent fires from burning over the area while trees are young.

Burning or cutting pole-size or smaller bur oaks results in vigorous stump sprouting, but sprout quality and form are poor.

Intermediate Treatments

Bur oak is intermediate in shade tolerance. Use intermediate cuttings to manage species composition according to the site. Prairie burning on upland sites is a common practice to kill invading brush and sustain prairie grasses. Older bur oaks withstand burns quite well.

Pests and Diseases

Bur oak is attacked by several defoliating insects, including oak webworms, oak skeletonizers, a leaf miner, variable oakleaf caterpillars, June beetles, and oak lacebugs. Oak wilt is a less serious problem in bur oak than in members of the red oak

group, although the disease sometimes spreads through root grafts, killing entire groves. Bur oak is susceptible to attack by root rot, canker, and dieback diseases. It tolerates urban pollution better than most oaks. Young trees are susceptible to fire, but older trees develop thick bark that is fire resistant.

Eastern White Pine

Eastern white pine often occurs in pure stands, especially in the eastern portion of its range (Figure 6-8), but may have a balsam fir understory in the northern Lake States. It is a pioneer species on abandoned agricultural land and in the northern Lake States may succeed red pine. On drier, sandier soils it approaches permanence as a sustainable forest type. On heavy-textured soils, white pine usually is succeeded by sugar maple-beech-yellow birch, white pine-hemlock, sugar maple-basswood, or white oak types.

Figure 6-8. Range of eastern white pine.

Products and Uses

Eastern white pine is used mainly for lumber. Some songbirds, squirrels, and small mammals feed on its seeds. Bark and foliage are consumed by beaver, snowshoe hares, rabbits, porcupine, red and gray squirrels, mice, and white-tailed deer. Bears use large white pines as escape cover for their cubs and they use young dense stands for shelter during inclement weather.

Site Conditions

White pine grows on nearly all the soils within its range, but competes best on well-drained sandy soils of low to medium site quality. On medium-textured soils (sandy loams), it will out-produce most other native species in both volume and value. White pine also grows on fine sandy loams and silt-loam soils with either good or impeded drainage when there is no hardwood competition during the establishment period—as on old fields and pastures, burns, and blowdowns. Do not plant white pine on heavy clay soils, poorly drained bottomland sites, and upland depressions. Avoid planting in depressions, bases of slopes, narrow V-shaped valleys, or small openings in dense forests that favor the collection of cool, moist air that encourages the spread of white pine blister rust. Site index curves are in Appendix B-7 on page 203.

Regeneration

White pine commonly lives 200 years and may live up to 450 years. Sawlog rotations usually are 80 to 120 years, but longer rotations are feasible to produce a stand with old-growth characteristics.

Reliable seed production begins when trees are 20 to 30 years old, and good seed years occur every three to five years. Seeds mature in August and September and are dispersed within a month by wind (200 feet within a stand, 700 feet in the open) and squirrels.

Seeds can germinate and survive on both disturbed and undisturbed litter layers. Under full exposure to sunlight, favorable seedbeds include moist mineral soil, polytrichum moss, or a short grass cover of light to medium density. Unfavorable seedbeds include dry mineral soil, pine litter, lichen, and very thin or very thick grass cover. Unfavorable seedbed conditions can be corrected by scarifi-

cation or overstory shade; however, dense, low shade, such as that cast by slash piles or hardwood brush, hinders seedling survival.

Regenerate white pine by clearcutting, seed tree, shelterwood, or group selection. If there is abundant advanced reproduction, remove the overstory to release the white pines. Clearcutting during or just after heavy seed crops often results in well-stocked stands on light soils. Clearcutting in small patches or stands with seed dispersed from adjacent stands is also possible. Because of competition from other vegetation and poor seed crops, mechanical site preparation and planting may be necessary with clearcutting.

A two-cut shelterwood system probably is the most reliable method for natural regeneration. Ten years before the final harvest, remove 40 to 60 percent of the overstory (no more than 30 to 40 percent of the basal area), preferably ideally in the year before or during a good seed year. Harvest during snowless months to scarify the site and expose mineral soil. Remove hardwood regeneration during the harvest since hardwoods may seriously compete with pine seedlings. After 5 to 10 years, if white pine seedlings are abundant, clearcut the residual overstory. (Delay this harvest until the new white pines are 20 to 25 feet tall if you expect white pine weevil to be a problem.) If white pine regeneration is not satisfactory, you may need to again thin the overstory, control advance hardwood regeneration, and wait another 5 to 10 years before the final harvest. Consider planting white pine seedlings to increase the density to 500 to 600 seedlings an acre.

Mechanical site preparation and planting are required on bare land or in white pine stands that do not naturally regenerate. Plant 2-0 or 3-0 seedlings at rates up to 600 to 800 trees an acre (closer where heavy white pine weevil damage is expected). Plant under a light forest canopy to reduce weevil and white pine blister rust damage.

Intermediate Treatments

White pine is intermediate in shade tolerance. It will tolerate up to 80 percent shade, but achieves maximum height growth in as little as 45 percent full sunlight. In the seedling stage it is very susceptible to competition because its height growth is slow. If white pine survives to the sapling stage, it becomes a stronger competitor.

Pure natural stands of white pine almost never stagnate. Stagnation occurs when all trees grow at about the same rate, then growth slows due to competition. Because of differences in vigor, age, and site, differentiation into crown and diameter classes usually occurs. You do not need to thin white pine seedling and sapling stands, but if a hardwood overstory develops, partially remove it to maintain 50 percent of full sunlight on the white pine. When trees average six to eight inches DBH, begin thinning and remove the hardwood overstory. Use the stocking chart for eastern white pine in Appendix C-3 as a thinning guide. When stands reach the A level, cut them back to the B level. Basal area after thinning should be about 100 square feet for young stands and 150 square feet for older stands.

Since white pine has persistent branches (that is, the lower branches don't self-prune as the tree ages), prune potential crop trees to a height of 17 feet to develop clear wood. Prune in the dormant season, removing limbs less than two inches in diameter. Maintain at least a 30 percent live-crown ratio. You can remove at least 25 percent of the live crown in open stands and up to 50 percent in closed stands without losses in height growth. Frequent light prunings are preferred to a single heavy pruning. Depending on local markets, pruning may not be economical.

Pests and Diseases

The most serious pests are white pine blister rust, white pine weevil, root rot, and deer browsing.

White pine blister rust can kill trees of any age. A local forester can advise you about the blister rust hazard in your area. Do not plant white pine in high-hazard zones. In medium and low-hazard zones, prune lower branches early to minimize the disease. Start pruning when white pines are more than two feet tall and continue until you've removed all branches within nine feet of the ground. Cut off infected limbs (shown by cankers or flag-

ging of dead needles). Trees with cankers on the main stem or on a branch within four inches of the main stem cannot be saved.

White pine weevils tunnel into the terminal leader, causing crooked or forked stems. If damage is present in small trees, clip wilted terminals in July and destroy the clipped terminals to remove weevils.

Reduce white pine weevil and blister rust damage by regenerating white pines under an overstory of hardwoods and releasing them slowly. When the pines are about 20 to 25 feet tall, remove the overstory.

White pines are a favorite food of deer. Protect seedlings with a budcap (Figure 6-9) or deer repellent.

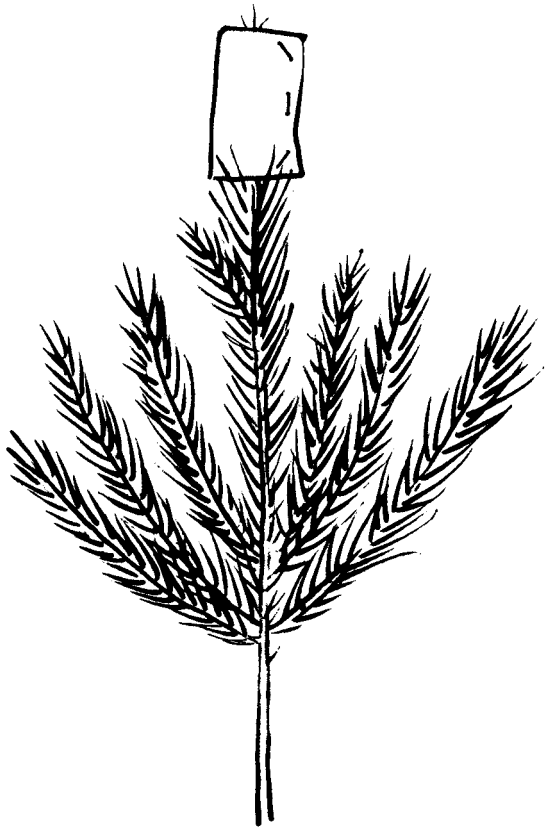

Figure 6-9. Bud capping protects young white pine from deer. Place a budcap on the main leader in fall. Cut lightweight paper into 4-inch by 6-inch pieces. Fold the paper around the leader, covering the top bud; fasten it with three staples that catch needles. Repeat annually until the trees are at least 4 feet tall.

Hemlock–Yellow Birch

This type occurs mainly in northern Wisconsin, Michigan's Upper Peninsula, and the northern portion of lower Michigan (Figure 6-10). Eastern hemlock and yellow birch are the principal species, with hemlock usually dominating. Common associates include red maple, sugar maple, and American basswood.

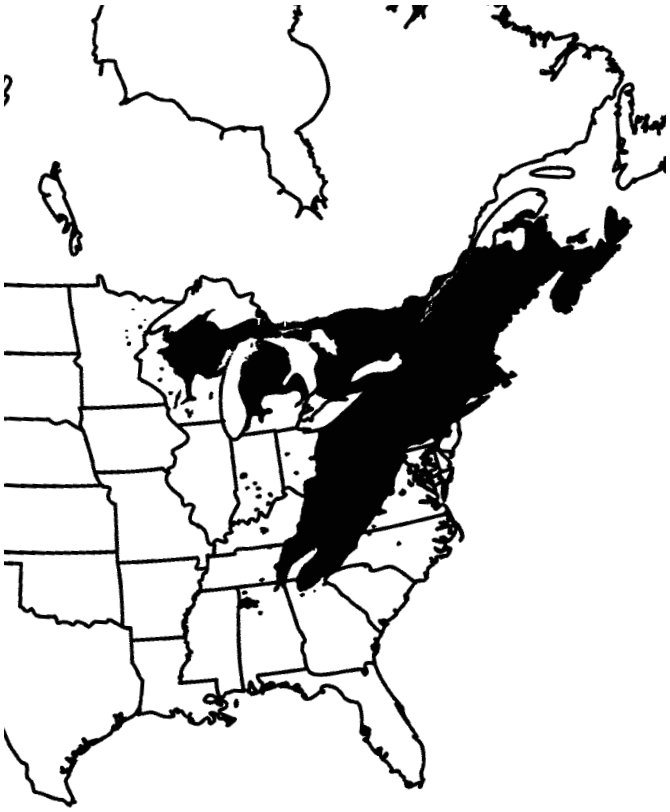

Figure 6-10. Range of eastern hemlock.

Products and Uses

Hemlock is used for paper and lumber. Yellow birch lumber and veneer are used in making furniture, paneling, plywood, cabinets, boxes, woodenware, handles, and interior doors. It is one of the principal hardwoods used in the distillation of wood alcohol, acetate of lime, charcoal, tar, and oils. Yellow birch is good browse for deer and moose. Other wildlife feed on the buds and seeds. Hemlock stands are essential for shelter and bedding of white-tailed deer during winter. The type also provides important cover for ruffed grouse, turkeys, and many other animals.

Site Conditions

Hemlock and yellow birch grow best on moist, well-drained sandy loam, loamy sand, and silt loam soils. Older stands typically occur on soils with a high water table and varying texture that develop a thick humus layer under a relatively low, dense overstory. As the site becomes drier, the type merges with sugar maple, sugar maple-beech-yellow birch, or beech-sugar maple. On wetter sites, hemlock-yellow birch frequently merges into the hemlock and white pine-hemlock types and on the wettest sites with the black ash-American elm-red maple type.

Regeneration

Eastern hemlock is a slow-growing, long-lived tree that grows well in shade. It may take 250 years to reach maturity and may live over 800 years.

Hemlock begins producing seed at age 15 and good seed crops occur every other year. Seeds fall from mid-October through early winter, but are dispersed only about one tree height in distance. Hemlock requires a warm, moist site for stand establishment, but successful regeneration is difficult to achieve. Seed viability is low. Seeds require temperatures of about 44˚ to 64˚ F for 45 to 60 days to germinate (longer than most tree species require). Seeds are severely damaged after only two hours of drying, and seedlings are subject to damping-off and root rot fungi.

Yellow birch begins producing good seed crops at age 40 in dense stands, and good crops occur every two to three years. Seeds are dispersed by wind primarily in October. Good seed fall occurs at least 330 feet from seed-bearing trees and seed can disperse much farther when blown across crusted snow. Yellow birch seedlings and small saplings reproduce from sprouts when cut, but sprouting from larger stems is very poor.

Regeneration of this type is most successful on moist flats or sites providing some protection from extended periods of sunlight. Use a shelterwood system that leaves 70 to 80 percent crown cover for optimum hemlock regeneration or 45 to 50 percent crown cover for optimum yellow birch regeneration. Kill advance regeneration and remove litter with a spring fire or scarify the site, mixing organic and mineral soil over 50 to 75 percent of the area. Plan treatments to coincide with good seed crops because the effects of scarification last only two or three growing seasons.

Without these conditions most eastern hemlock and yellow birch regeneration occurs on rotten logs, stumps, and mounds that normally have warmer surfaces and better moisture retention than the forest floor.

Seedlings develop slowly even under ideal growing conditions, with stable moisture in the upper soil horizon throughout the growing season. Once the root system has reached a soil depth not radically affected by surface drying, usually after the second year, seedlings grow more rapidly without interference from overhead shade. Supplemental seeding would enhance natural seeding under most conditions. Seedlings are fully established when they are 3 to 5 feet tall, and then can be released completely from overhead competition.

Survival and height growth of planted hemlock (3-0 stock) and yellow birch (2-0 stock) usually is good in small openings or under a partial overstory. To artificially seed birch, stratify seed for 4 to 8 weeks at 41˚ F in moist peat or sand. Spread 0.5 lb an acre of birch seed about a week after site preparation in May, or sow unstratified seed before January.

Intermediate Treatments

Both hemlock and yellow birch are very slow growing species, but hemlock is longer lived, commonly surviving to 400 years of age.

Eastern hemlock is the most shade tolerant of all tree species and can withstand suppression for 400 years. Yellow birch is intermediate in shade tolerance. Within five years of regeneration, yellow birch seedlings may require release from faster growing species. In the sapling stage, thin stands to provide 6 to 8 feet of open space around the best dominant and codominant trees. Continue periodically releasing dominant and codominant trees through the small sawlog stage. However,

excessive release of hemlock may reduce growth, increase mortality, and contribute to windthrow. Heavy release of yellow birch results in epicormic branches that degrade the stem.

In mixed stands of hardwoods and hemlock, where the proportion of hemlock is 15 percent or more, it is feasible to manage for hemlock at various residual stocking levels. Hemlock does not require as much growing space as hardwoods, so residual stocking is greater in stands where hemlock predominates. Stands with less than 15 percent hemlock should be managed for hardwoods.

When thinning stands exceeding 200 square feet an acre of basal area, remove no more than one-third of the total basal area at one time. Excessive cutting results in reduced growth and increased mortality and contributes to windthrow. In addition, hardwood encroachment interferes with the successful establishment of hemlock. Fully stocked stands with basal areas of less than 200 square feet an acre can be thinned to a minimum of 120 square feet an acre.

Yellow birch prunes itself well so long as its crown is allowed to close within five or six years after release. It can, however, be pruned to 50 percent of its height without reducing growth. Prune small, fast-growing trees with small knotty cores to limit discoloration and decay.

Pests and Diseases

Young hemlock seedlings are often damaged by desiccation, damping-off fungi and root rot. In the Eastern United States, the hemlock woolly adelgid is a serious insect pest that feeds on needles. It is expected to reach the Lake States sometime in the future. Young hemlock and birch are susceptible to fire damage. The bronze birch borer is the most serious insect pest of yellow birch. Mature and overmature trees left severely exposed after logging and in lightly stocked stands are more subject to attack than are trees in well-stocked stands. Yellow birch is a preferred food of snowshoe hare and white-tailed deer. Overmature birch are subject to canker diseases, root rots, and stem decay. Birch is not a preferred host for leaf-feeding insects, but severe outbreaks that last several years will kill birch.

Jack Pine

Jack pine (Figure 6-11) usually grows in pure stands, but may be mixed with northern pin oak, red pine, quaking aspen, paper birch, and balsam fir. On moist sites in the northern Lake States, jack pine may succeed to red pine to eastern white pine to hardwoods (such as sugar maple, basswood, and northern red oak).

Figure 6-11. Range of jack pine.

Products and Uses

Jack pine is used mainly for pulpwood, poles, and small sawlogs. It is moderately useful deer browse. Dense, young stands provide cover for snowshoe hares. Dense sapling and poletimber stands offer some wildlife shelter, but not as much as most other conifers. The Kirtland's warbler, an endangered species of bird that nests only in Michigan, requires homogeneous jack pine stands that cover more than 80 acres and and have trees that are 5 to 20 feet tall with branches that reach the ground. Older jack pine stands usually are less dense than other conifer stands, permitting the growth of understory shrubs and herbaceous plants that provide food and cover for wildlife.

Site Conditions

Jack pine commonly grows on level to gently rolling sand plains. It occurs less commonly on eskers, sand dunes, rock outcrops, and bald rock ridges. It grows best on well-drained loamy sands where the midsummer water table is 4 to 6 feet below the surface. Jack pine does well on moderately acidic soils, but it will tolerate slightly alkaline conditions. It grows poorly on shallow bedrock and heavy clay soil. Jack pine survives and grows better than other tree species on dry sandy soils. On better sites, convert the stand to species that are more productive and valuable for wood products. Site index curves for jack pine are shown in Appendix B-9 on page 204.

Regeneration

Although jack pine is short-lived, stands sometimes survive for 100 years. Plan a rotation age of 40 to 50 years for pulpwood and 60 to 70 years for poles and sawtimber. Mature trees range from 8 to 12 inches DBH.

Jack pines typically begin producing seeds when they are 5 to 10 years old under open-crown conditions, but later when growing in dense stands. The best seed production occurs in trees that are 40 to 50 years old. Seed production is fairly regular and increases until crown competition becomes a factor. Some seed is usually produced every year and total crop failures are rare. Jack pine cones in parts of the range are serotinous—that is, they remain closed at maturity. Serotinous cones open most readily during dry weather when the temperature is at least 80° F, although many remain closed until they are exposed to fire or high temperatures (122° F) near the ground after wind breakage or logging. Nonserotinous cones may disseminate seeds during any season. Jack pine seeds are dispersed by wind about two tree heights.

Seedling survival is highest on mineral soil and burned seedbeds where competition from other vegetation is not severe, the water table is high, and there is light shade primarily from scattered slash. Heavy slash must be reduced by full-tree skidding, burning with a hot fire, chopping, disking, or dragging. Shrubs and other competition can be controlled by full-tree skidding, machine scalping, disking, roller-chopping, bulldozing, shearing, rock or root raking, or using herbicides. Clearcutting creates the best conditions for regeneration, but seed tree or shelterwood systems may be appropriate depending on the stand and site conditions.

Clearcut where a new stand will be established by planting improved seedlings, direct seeding, or scattering serotinous cones from high-quality trees. The sun's heat near the ground surface will open serotinous cones and release the seed. If the mature stand is not a suitable seed source, burn the site to destroy slash and plant or seed the area using a desirable seed source.

The seed-tree system may work satisfactorily where you have 10 well-distributed, desirable quality seed trees an acre with an abundant supply of nonserotinous cones. After the harvest, burn the area to consume slash, kill competition, and prepare a favorable seedbed. Burn slash as soon as possible after harvest to minimize the risk of seed trees windthrowing before they cast seed. Jack pine slash requires a month of warm, dry weather to cure sufficiently to burn. Early spring fires permit seeding during the most favorable season, but late fall burning and seeding may be almost as effective if rodent populations are low.

Consider the shelterwood system in well-stocked stands with nonserotinous cones. Treat competition and slash as described earlier. Cut the stand to leave 30 to 40 square feet of basal area an acre in desirable seed trees. Remove the shelterwood overstory when there are 600 seedlings an acre or within 10 years.

Direct seeding in early spring may be successful where the water table is within a few feet of the surface or there is frequent precipitation during germination and early seedling development. Coat the seed with bird and rodent repellents and sow it at the rate of 20,000 viable seeds an acre.

Where direct seeding has failed, or on deep, dry sandy soils, plant bare-root seedlings in spring or container-grown stock into early summer. Plant at a 6- to 8-foot spacing.

Jack pine is a pioneer type on nearly all sites except dry, sandy soils. On better sites facilitate the successional trend by harvesting jack pines in several cuts to encourage the growth of other species, or clearcut and plant another species, usually red pine or white spruce, depending on the site.

Intermediate Treatments

Jack pine is very intolerant of shade. On better sites with substantial hardwood competition, control brush with herbicides when it threatens to overtop jack pines.

Most natural jack pine stands are understocked. To prevent stagnation in dense seedling and sapling stands with more than 2,000 trees an acre, weed out undesirable trees, leaving 800 to 1,000 uniformly spaced crop trees. In very dense seedling stands (for example, with 10,000 trees an acre) it is less expensive to mechanically clear strips about 8 feet wide and leave strips about 2 feet wide. On good sites (with a site index of 60 or more) where sawtimber is desired, thin pole-sized stands to 80 square feet of basal area an acre or follow the stocking chart in Appendix C-4 on page 209. Do not remove more than one-third of the basal area during any one thinning. Pruning is not recommended.

Pests and Diseases

Common insect pests of jack pine include bark beetles and jack pine budworm. Stem rusts, heart rot, root rot, and stem cankers are important diseases. Fire damages trees of all sizes. Deer browsing, snowshoe hare girdling, and porcupine bark stripping may cause significant mortality when animal populations are high.

Drought and injuries increase losses to insects and diseases. To minimize pest problems, keep stands growing vigorously. Thin regularly, removing suppressed and low-vigor trees while avoiding damage to residual trees. Harvest stands by age 50 (or by age 70 where the site index is greater than 70). Do not reproduce jack pine where the site index is less than 55.

To avoid bark beetle damage, do not harvest or thin the stand from January through August unless you destroy all slash greater than two inches in diameter within three weeks of cutting. Destroy the slash by piling and burning, chipping, or burying. Avoid wounding trees during thinning. If trees are damaged by fire, windstorms, or logging, harvest them, remove the logs from the woodland, and destroy the slash within three weeks.

Maple–Beech–Yellow Birch

This collection of forest types, often called northern hardwoods, includes several mixes: sugar maple, sugar maple-beech-yellow birch, sugar maple-basswood, beech-sugar maple, and red maple. The dominant species varies with the type, as named, but common associates, depending on the site and geographic range of species, include white ash, green ash, black ash, black cherry, northern red oak, white pine, balsam fir, American elm, hackberry, bitternut hickory, white spruce, ironwood, eastern hemlock, northern white-cedar, paper birch, aspen, and pin cherry. Beech and hemlock occur in eastern Wisconsin and Michigan (Figure 6-12).

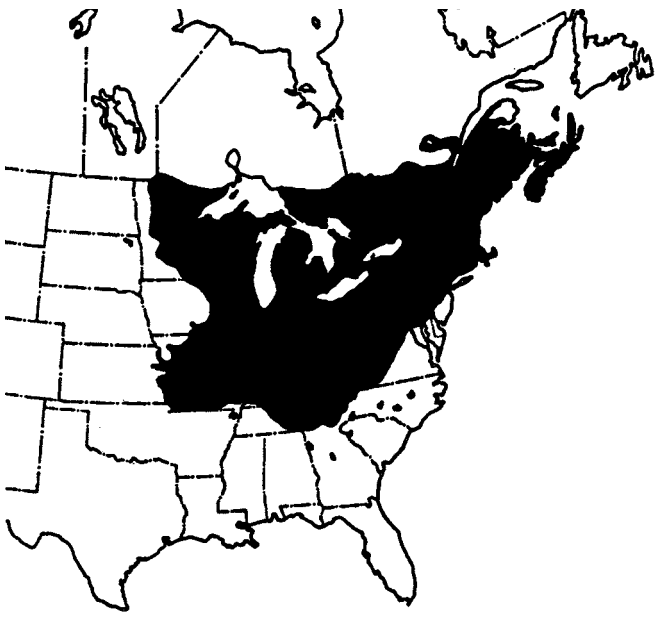

Figure 6-12. Range of sugar maple

Products and Uses

This collection of forest types includes numerous tree species. Sawlogs, veneer logs, pulpwood, and firewood are the major wood products from them. Maple syrup is made from sugar maple sap. These forests provide habitat for a variety of wildlife, including deer, bear, squirrel, ruffed grouse, and woodcock.

Site Conditions

Northern hardwoods grow on sands, loamy sands, sandy loams, loams, and silt loams, but they grow best on moist, moderately to well-drained, fertile, loamy soil. Beech favors drier sites while yellow birch favors moister sites. The poorest sites occur on soils that are infertile, dry, shallow, or swampy. Site index comparisons among hardwoods are shown in Appendix B-8 on page 203.

Regeneration

Northern hardwoods include species that are long-lived and shade tolerant that form self-perpetuating climax plant communities.

The major species produce abundant seeds, but sometimes at irregular intervals. Beech, elm, basswood, and red maple sprout prolifically from stumps. The stumps of young trees sprout more prolifically than those of older trees. Only the sprouts of basswood and sprouts from seedlings and saplings under 2 inches DBH on other species are desirable for reproduction.

Sugar maple, beech, hemlock, and balsam fir are very shade tolerant. Basswood, northern white-cedar and white spruce are tolerant. Yellow birch, white ash, red maple, red oak, bitternut hickory, and white pine are intermediate. Green ash and hackberry are intermediate to intolerant. Black ash, paper birch, aspen, and black cherry are intolerant of shade.

Selection, shelterwood, or clearcutting methods can be used successfully in these types of stands, depending on the species mix of the current stand, advance regeneration, site quality, and desired future species mix.

If high-quality, very shade tolerant species are desired, use single-tree selection or group selection methods. Harvest about every 15 years, leaving roughly 70 square feet of basal area. Do not leave less than 50 or more than 95 square feet of basal area in trees of more than 10 inches DBH. Alternatively, mark the stand for harvest as shown in Table 6-2. Cut mainly trees that have no potential for further economic growth or that interfere with the growth of better trees, then cut mature trees. This system produces an uneven-aged stand.

Table 6-2. Desirable stocking an acre for uneven-aged management of northern hardwoods.

DBH in Inches	Residual Number of Trees Per Acre	Basal Area in Square Feet
5	21	2.9
6	15	2.9
7	12	3.2
8	9	3.1
9	8	3.5
Subtotal	65	16.0
10	7	3.8
11	6	4.0
12	5	3.9
13	5	4.6
14	5	5.3
Subtotal	28	22.0
15	4	4.9
16	4	5.6
17	3	4.7
18	3	5.3
19	3	5.9
Subtotal	17	26.0
20	2	4.4
21	2	4.8
22	2	5.3
23	1	2.9
24	1	3.1
Subtotal	8	20.0
Total	118	84.0

SOURCE: Hutchinson, J. A. (ed.). Northern Hardwood Notes (Note 4.03). U.S. Government Printing Office, Washington, DC 20402.

To achieve an even-aged stand dominated by sugar maple, use a two-cut shelterwood system. Harvest in winter, preferably when there is snow cover to protect advance regeneration, and leave 60 percent crown cover after the first harvest. Leave good quality dominant trees for a seed source. Remove intermediate and codominant trees, defective trees, and undesirable species. Make the second cut after advance regeneration is 2 to 4 feet high. If you prefer a greater variety of species, use a two-cut shelterwood system following these guidelines:

- Eliminate all reproduction present before cutting.
- Harvest in any season except summer.
- Scarify the site during harvest.
- Leave 70 to 80 percent crown cover.
- Remove undesirable seed sources.
- Make the second cut after advance regeneration is 3 to 4 feet high.

To encourage yellow birch, focus on cool, moist sites. Discriminate against sugar maple in the residual overstory when marking the stand for shelterwood harvest. In open sawlog stands, after leaf fall, but before logging, scarify at least 50 percent of the site to mix humus with mineral soil while destroying advance regeneration; then harvest. In dense stands where mechanical scarification is not practical and on wetter sites, harvest to leave about 70 percent crown cover, then use prescribed fire to remove the litter and destroy advance regeneration.

Planting seedlings is rarely necessary, but is appropriate for open fields or under a shelterwood stand to change the species composition. In open fields plant only in fertile, well-drained soil. Thoroughly disk before planting, plant tap-rooted species such as white ash and northern red oak, plant only when there is good soil moisture, and control weeds for one to three years after planting. Under shelterwoods, kill undesirable understory plants and plant in the most open areas immediately after site preparation.

Where aspen is mixed with more shade-tolerant northern hardwood species, decide whether to encourage aspen or the other species. If there is an overstory of aspen and an understory of hardwoods, you can favor the aspen by clearcutting the stand when aspen are marketable to stimulate aspen root suckering. Favor hardwoods by removing the aspen when the understory hardwoods are 1 to 3 inches DBH, taking great care to avoid damaging the hardwoods. If the aspen has little commercial value, consider killing it with herbicides and letting it stand.

If aspen and other hardwoods are of equal size, favor aspen by clearcutting the stand. To encourage hardwoods, thin or harvest the stand leaving 70 to 85 square feet of basal area an acre in trees 4.6 inches DBH and larger, discriminating against aspen, or follow the stocking chart for even-aged management of northern hardwoods (see Appendix C-5 on pg. 210).

Intermediate Treatments

When following the single-tree selection system in an uneven-aged stand, use Table 6-2 (pg. 76) to determine the approximate basal area and number of trees to leave after each harvest. Remove poor quality trees and undesirable species during the harvest.

In an even-aged sapling stand, release yellow birch saplings between 10 and 20 years of age by removing competing trees with crowns within 5 feet of the birch. Thin basswood and red maple sprouts to two or three of the straightest, least-defective stems.

Periodically thin even-aged pole stands. There are different stocking charts depending on the percentage of different tree species in the stand. Appendix C-5 (pg. 205) may be an appropriate stocking chart for many stands. As a general rule, do not reduce the basal area of trees 4.6 inches DBH or more to less than 60 square feet or leave more than 85 square feet. However, if basswood or hemlock are a significant part of the stand, the residual basal area can be increased.

Pests and Diseases

Logging equipment may damage remaining trees. In the next harvest remove trees with wounds

larger than 50 square inches. Canker diseases affect yellow birch and sugar maple. Frost cracks also degrade sugar maple in the northern part of its range. Organisms causing rot and stain enter trees through damaged roots, stems, and branches. To reduce volume and quality losses from these sources, train heavy equipment operators to avoid damaging trees, maintain healthy stands, remove infected stems, and keep rotations less than 120 years.

Northern Pin Oak

Northern pin oak occurs in pure stands or in varying mixtures with white oak, black oak, bur oak, northern red oak or jack pine. It also may be associated with red pine, eastern white pine, quaking aspen, bigtooth aspen, red maple, black cherry, and paper birch. It occurs mainly in east central Minnesota, central and northern Wisconsin, and central Michigan.

Products and Uses

Timber quality tends to be poor, but northern pin oak is marketed as a red oak for lumber, railroad ties, and firewood. Northern pin oak acorns are important food for deer, turkeys, squirrels, ruffed grouse, and many other birds and small mammals.

Site Conditions

Northern pin oak commonly grows on dry, acid, sandy soils with a very thin organic layer in sand plains and on gravelly slopes. On better quality sites, conversion to other oaks, red pine, jack pine, or white pine is recommended for timber production.

Regeneration

As a minor forest type and a species with low economic value, little information is available about northern pin oak regeneration and management. It is intolerant of shade and will not reproduce under its own shade. Other oaks and white pine are less light demanding and tend to succeed it.

Acorns drop in the fall and germinate the following spring. The interval between good seed crops is estimated to be two to five years. Acorn weevils and wildlife consume a large portion of the acorn crop, especially in poor seed years. Acorns fall below the canopy, but are dispersed much further by squirrels, blue jays, and other animals. Northern pin oak naturally regenerates on dry sites where few other tree species can survive. Natural regeneration is unreliable under poor site conditions, but can be increased by clearcutting oaks in the fall soon after a good acorn crop has dispersed. Scarify the site during logging by dragging a tree top across the site to help bury acorns. Planting acorns or seedlings of oak or pine is recommended to help ensure regeneration.

Intermediate Treatments

Stand density is likely to be low because of poor site quality, but use intermediate harvests to thin dense patches, remove low quality trees, and adjust species composition. While northern pin oak is a satisfactory species for wildlife, in stands where your goal is timber production, favor other oaks and pines over northern pin oak during thinnings.

Pests and Diseases

Oak wilt is a serious disease. Avoid wounding trees from April through July when insects that transport the disease are most active.

Northern White-Cedar

The northern white-cedar type of woodland occurs in the northern Lake States (Figure 6-13) where common associates on wetter sites are balsam fir, tamarack, black spruce, white spruce, black ash, and red maple. Yellow birch, paper birch, quaking aspen, bigtooth aspen, balsam poplar, eastern hemlock, and eastern white pine are common on better drained sites.

Products and Uses

The rot- and termite-resistant wood is used principally for products in contact with water and soil, such as rustic fencing and posts, cabin logs, lumber, poles, and shingles. Smaller amounts are used for paneling, piling, novelties, and woodenware. Cedar leaf oil is distilled from boughs and used in medicines and perfumes; boughs are also used

in floral arrangements. The northern white-cedar type is valuable for white-tailed deer shelter and browse in winter. It is also used by snowshoe hare, porcupine, red squirrel and in summer by several songbird species.

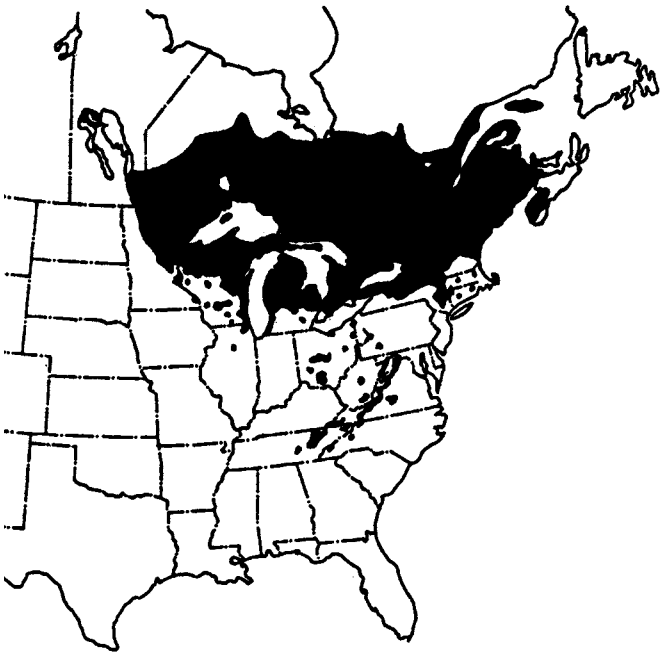

Figure 6-13. Range of northern white-cedar.

Site Conditions

Northern white-cedar grows on a wide variety of organic soils and mineral soils, but it grows best on limestone-derived soils that are neutral or slightly alkaline (pH of 5.5 to 7.2) and moist but well-drained. It does not develop well on extremely wet or extremely dry sites. It is usually dominant in swamps with a strong flow of moderately mineral-rich soil water. The organic soil (peat) is usually moderately to well decomposed, 1 to 6 feet thick, and often contains much rotted wood. It also can dominate peat ridges in bogs that have a sluggish movement of water weakly enriched with nutrients. On upland sites with mineral soil, it occurs on seepage areas, limestone uplands, and old fields.

Site index curves for northern white-cedar are shown in Appendix B-10 (see pg. 204). Manage for timber only where the site index exceeds 25.

Regeneration

Rotation lengths range from 70 years for posts up to 160 years for poles or small sawlogs. For optimum deer shelter, plan rotations of at least 110 years.

Northern white-cedar reproduces successfully from both seed and layering. Good seed production begins at age 30, but peaks after age 70. Most seeds drop from mid-September to late October, but some drop during winter. They are wind-dispersed up to 200 feet.

Germination and seedling development is best where there is a constant moisture supply, warm temperatures, and pH of 6.6 to 7.2. On undisturbed areas, seedbeds on rotten logs and stumps account for more than 70 percent of the seedlings. On undisturbed areas, seedlings prosper on both upland and swamp burns. Burning must be fairly severe to expose favorable mineral soil seedbeds on uplands or to improve moss seedbeds in swamps. White-cedar seedlings also reproduce well on skid roads where compacted moss stays moist. Light slash cover is better than none, but heavy slash cover hinders seedling establishment.

Moisture is often the most important factor during the first few years, but expect seedlings to be tallest when grown in about half sunlight and expect shoots and roots to be heaviest in full light. In areas with frequent hot, dry spells, partial overstory shade is necessary to reduce losses from drought and herbaceous competition.

Northern white-cedar can send out roots from any part of a branch or stem if moisture conditions are favorable. Layering frequently occurs in swamps, especially on poor sites with abundant sphagnum moss. Sprouts from roots or stumps are rare.

Northern white-cedar is shade-tolerant and can be managed under single-tree selection or clearcutting systems. A clearcut or shelterwood harvest followed by natural seeding is the usual regeneration method. If advance reproduction is not present, a combination of clearcut and shelterwood strips is recommended to optimize natural seeding. Strips

vary from one chain wide where seedbearing trees are less than 35 feet tall to two chains where these trees are more than 60 feet tall. Use either alternate or progressive strips. If you use alternate strips, clearcut one set, then cut the adjoining strip in two stages using the shelterwood system about 10 years later. For the first stage of the shelterwood, leave a basal area of 60 square feet an acre in uniformly spaced dominant and codominant trees of desirable species. Select residual trees for good seed production, wind-firmness, and timber quality. The second stage of the shelterwood, the final clearcut, should occur about 10 years after the seed cut. If you use progressive strips, work with sets of three—the first two being clearcut at one-year intervals and the third one cut in two stages as previously described.

You may need to control associated trees before the final harvest if you want to obtain 50 to 80 percent white-cedar on good sites managed for timber or deer habitat. Kill undesirable trees (especially hardwoods) that reproduce by root suckers or stump sprouts at least 5 and preferably 10 years before reproduction cutting.

Rely on residual stems to reproduce a stand only if there are at least 600 stems an acre of relatively young (less than 50 years old) and healthy white-cedars remaining. Remove heavy slash that buries residual stems or seedbeds. Full-tree skidding in winter will remove most slash and is recommended where residual trees will be relied on for reproduction. Either full-tree skidding or burning may be used for slash disposal in clearcut strips.

Intermediate Treatments

A mixed species stand with 50 to 80 percent white-cedar is best for multiple-use purposes. Young stands of white-cedar that are overtopped by shrubs or hardwoods may benefit from an herbicide release, providing there is no surface water nearby that could be contaminated by an herbicide. Alder, black ash, aspen, paper birch, willow, red maple, and balsam poplar are the main competitors to be controlled.

To produce timber, thin middle-aged stands initially to a residual basal area of 130 square feet, then thin at 10-year intervals to around 90 square feet, favoring dominant and codominant trees. Thinning below 150 square feet may stimulate advance tree reproduction and shrubs.

Pests and Diseases

White-cedar is relatively free of major insect and disease problems. Wind may cause breakage and uprooting, mainly along stand edges and in stands opened up by partial cutting. White-tailed deer and snowshoe hare commonly browse northern white-cedar so severely that stands cannot become established. Overbrowsing may be minimized when regenerating stands if large patches (40 acres or more) are completely cleared. Roads, beaver dams, and pipelines that impede the normal movement of soil water will kill northern white-cedar.

Red Pine

In the northern Lake States red pine grows in extensive pure stands (Figure 6-14), but more often it is found with jack pine, eastern white pine, or sometimes northern pin oak. On coarser, drier soils, common associates are jack pine, quaking aspen, bigtooth aspen, northern pin oak, and bear oak. On somewhat better soils (fine sands to loamy sands), in addition to the species mentioned earlier, associates may be eastern white pine, red maple, black cherry, northern red oak, white oak, balsam fir, black spruce, and occasional specimens of the better hardwoods. On sandy loam and loam soils, red pine's associates include sugar maple, eastern white pine, American basswood, red maple, balsam fir, paper birch, yellow birch, American beech, northern red oak, eastern hemlock, white spruce, white ash, northern white-cedar, and eastern hop hornbeam.

In the absence of fire or other catastrophes, ecological succession in the Lake States is from jack pine to red pine to white pine, and finally to northern hardwoods or spruce-fir. On coarser, more infertile sands, succession may stop with red pine.

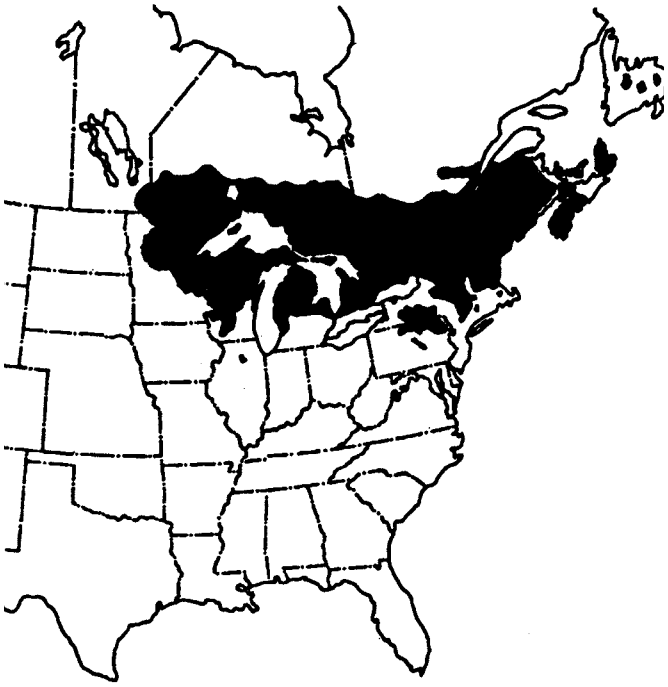

Figure 6-14. Range of red pine.

Products and Uses

Red pine is grown primarily for lumber, pulpwood, piling, poles, cabin logs, railway ties, posts, mine timbers, box boards, and fuel. Red pine stands generally provide poor habitat for game birds and animals, but old-growth trees are used as nesting sites by bald eagles and many songbirds. Open canopy stands with a shrub understory offer better wildlife habitat than closed canopy stands.

Site Conditions

In the Lake States red pine commonly grows on level or gently rolling sand plains or on low ridges adjacent to lakes and swamps, but not in swamps. It occurs mainly on dry, sandy soils low in fertility, but is also found on organic debris over rock outcrops and some red clays where it may be stunted. It grows well on silt loams, but not on heavier soils. It grows especially well on naturally subirrigated soils with well-aerated surface layers and a water table 4 to 9 feet deep. Best plantation development is on soils ranging from moderately drained to moist. It prefers a pH of 4.5 to 6.0. Site index curves are in Appendix B-11 (see pg. 205).

Regeneration

For wood production the recommended rotation age for red pine is 60 to 90 years. However, red pine is a long-lived species, providing opportunities to grow stands for 200 years and individual trees to even greater ages.

Seed production begins when trees are 15 to 25 years old in open grown trees and 50 to 60 years old in closed stands, but it peaks in trees 50 to 150 years of age. Good seed crops occur at three- to seven-year intervals. Seeds may be disseminated up to 900 feet by wind, but the effective range averages only 40 feet. The heaviest seedfall occurs within a month after cones fully ripen in autumn, but seedfall continues through winter and into the next summer.

Red pine may naturally regenerate where there is a fine sand seedbed, thin layer of moss or litter, a water table within 4 feet of the soil surface, and some shade (25 to 45 percent of full sunlight). A summer fire provides a satisfactory seedbed, kills some competing trees and shrubs, reduces cone insect populations, and produces an open overstory canopy. Other requirements for good natural regeneration include a good red pine seed crop, not too thick a layer of ashes, 4 inches of rainfall from May through July, and subsequent freedom from fire for several decades. If rainfall is deficient, seeds can lie over for one to three years before germinating. Such conditions may occur only once in 75 to 100 years.

After seedlings have grown above the sparse ground cover that favored germination and early survival, the number of seedlings and height growth increases with light up to full daylight. Red pine is shade intolerant.

Because natural regeneration is unreliable, clearcutting followed by planting is the most common regeneration method. Common spacings are 6 feet by 8 feet and 6 feet by 10 feet. Trees can be planted at wider spacings (up to 10 feet by 10 feet) if high survival is expected. Closer spacing reduces tree taper and branch size, promotes early crown closure, and suppresses competition, but also requires

more frequent thinnings. If precommercial thinnings are not feasible, avoid close spacing.

The most common planting stock is 3-0 bareroot seedlings, but 2-0 seedlings sometimes are used. On difficult sites use transplants or the largest seedlings available. To extend the planting season, use containerized seedlings.

Site preparation should reduce competition for light, water, and nutrients without causing any serious soil loss. Full-tree skidding to remove slash may be all that is needed, but most sites require shrub control and mineral soil exposure. Mechanical methods of controlling competition may include disk trenching, Brakee plow, roller chopping, brush raking, or scalping. Herbicides are very effective at killing undesirable trees and shrubs in red pine stands. Prescribed burning is less effective than herbicides, but can reduce slash and set back woody competition. Conifer slash can be burned almost immediately after harvest, but hardwood slash needs several weeks to cure. In mature red pine stands, use one or more summer firesthe very cautious use of summer prescribed burning may be used to eliminate shrubs and reduce duff before harvesting.

Intermediate Treatments

Cultural practices are needed to keep red pine crop trees free from overhead shade and faster growing competitors. Red pine seedlings may need a complete release from shrubs and other low competition by the second or third growing season. Release plantations overtopped by hardwoods as soon as possible. Herbicides are the most efficient means to control competition. Apply spray after pine leader growth is complete and the terminal bud is set (around mid-July), and before the end of the growing season. Instead of herbicides, consider using a hand-held, motorized brush cutter, recognizing that hardwoods will resprout and may need cutting again in a few years.

In seedling stands (less than 2 inches average DBH) with more than 2,000 trees an acre, at least 100 potential crop trees should be given a minimum growing space of 25 square feet each. Dense sapling stands (2 to 5 inches average DBH) with 160 square feet or more of basal area an acre should be thinned to give 50 square feet of growing space an tree. For stands averaging 5 inches in diameter, minimum recommended stocking is about 400 trees (60 square feet basal area) an acre while the upper limit is about 1100 trees (150 square feet basal area). The stocking chart for red pine (see Appendix C-6 on pg. 210) provides guidelines for thinning pole and sawtimber stands. Pole stands (5 to 9 inches DBH) with greater than 140 square feet of basal area an acre should be thinned to about 90 square feet of basal area an acre. Small sawtimber stands (9 to 15 inches average DBH) grow well at densities around 120 square feet of basal area an acre. Large sawtimber (15 inches or larger average DBH) can be managed at densities of 150 to 180 square feet of basal area an acre.

As a general rule, remove less than half of the basal area in any one thinning, and during early thinnings, cut trees that are smaller, slower growing, and of poorer quality than the stand average. The remaining trees should have a live crown ratio of 30 to 40 percent. In mixed-species stands, favor red pine crop trees at each thinning or leave other species for greater biodiversity, better wildlife habitat, or more diverse timber products.

To encourage natural pruning, plant red pine seedlings at high densities (about 800 trees an acre). Since red pines may not self-prune until age 40, you can improve tree quality by clear-stem pruning at least 17 feet high. Begin pruning when trees reach 4 to 6 inches DBH. Prune only the best dominant and codominant trees, removing live branches less than 2 inches in diameter and all dead branches. Prune in late fall to early spring.

Pests and Diseases

Red pine may be killed or damaged by fire, ice and sleet storms, very strong winds, de-icing salt spray along highways, and spring flooding lasting 20 days or more.

Several sawflies and jack pine budworm defoliate and may kill seedlings and damage older trees. Control them with insecticides where needed. The

Saratoga spittlebug, which often damages young plantations, may be controlled by removing sweetfern, its alternate host. White grubs cut seedling roots and may kill trees in dry years. Reduce the grub population by killing sod in plantations. Pine root collar weevils also injure or kill red pine. Reduce their habitat by pruning lower branches and raking up needles near the tree base. Bark beetles are very serious pests of red pine, particularly in dense stands on sandy soils during drought years. Bark beetles breed in recently cut or killed trees, stressed trees, freshly pruned or wounded trees or logging slash greater than 2 inches in diameter. Do not create breeding material from February 1 to September 1 in the northern Lake States or from March 1 to September 1 in the southern Lake States. Any breeding materials created during the breeding period must be removed from the site or destroyed as soon as possible.

Scleroderris canker, red pine shoot blight, diplodia, root rots, butt rots, and needle blights may be important in some areas. The best control measures are to remove infected trees and maintain stand vigor. Do not establish young red pine stands beneath or near infected older red pines.

High populations of snowshoe hares, cottontail rabbits, and mice often kill or reduce height growth of red pine seedlings. Eliminate protective grass to reduce their populations. When preferred foods are lacking, white-tailed deer browse and may destroy red pine seedlings. Manage your deer population or use bud caps or deer repellents. Porcupines girdle red pines from sapling to mature tree stages.

Silver Maple–American Elm

The silver maple-American elm forest type is common in the southern Lake States (Figure 6-15) on well-drained moist sites along river bottoms, floodplains, and lake shores. It often replaces stands that originally held cottonwood, willow, and red-osier dogwood. Other associates may include pin oak, green ash, red maple, basswood, black walnut, black cherry, hackberry, and box elder. American elm is no longer a major component of mature stands because of Dutch elm disease.

Figure 6-15. Range of silver maple.

Products and Uses

Silver maple, cottonwood, green ash, and associated hardwoods are used primarily for lumber, veneer, and firewood. In some areas cottonwood is used for pulpwood. Green ash is used in specialty items such as tool handles and baseball bats. A high number of wildlife species, especially birds, can be found in a mature bottomland hardwood forest. Mature and overmature stands provide cavities that are essential to many wildlife species, including woodpeckers, wood ducks, barred owls, and raccoons. White-tailed deer, beaver, and other fur-bearers also can be found in this forest type. Silver maple buds are a staple food for squirrels in the spring. Beavers feed on silver maple and cottonwood bark.

Site Conditions

Silver maple commonly is found on the alluvial flood plains of major rivers where there are moist, fine-textured silt and clay soils that are imperfectly drained. Its best growth is in better drained, moist areas. Soil pH should be above 4.0. Silver maple seedlings are intermediate in tolerance to water-saturated soils but can tolerate prolonged periods of inundation.

Green ash grows naturally on a range of sites from clay soils subject to frequent flooding and overflow to sandy or silty soils where the amount of available moisture may be limited. It grows best on fertile, moist, well-drained soils. Green ash commonly is found on alluvial soils along rivers and streams and less frequently in swamps. It can remain healthy when flooded for as long as 40 percent of the time during a growing season. Young green ash can withstand flooding for several months during the dormant and early growing season. It prefers a pH of between 7.5 and 8.0.

Cottonwood survives on deep, infertile sands and clays but makes its best growth on moist, well-drained, fine sandy or silt loams close to streams.

Stands with site indexes below 70 for green ash (see Appendix B-5 on pg. 202), eastern cottonwood (see Appendix B-6 on pg. 202), or silver maple should be managed for wildlife, aesthetics, or other nontimber uses.

Regeneration

Silver maples begin producing seed at about age 11. Seeds ripen from April through June. Dissemination is mainly by wind and occasionally by water. Natural regeneration is most successful on a seedbed of moist mineral soil with considerable organic matter. Initial seedling growth may be rapid, but because silver maples cannot compete with overtopping vegetation, first-year mortality is high if they are not released. The preferred size of seedlings for plantations is 12 inches in height and 0.25 inches in root-collar diameter. Sprouts appear readily from stumps that are 12 inches or less in diameter.

Green ash starts producing seed when trees are 3 to 4 inches DBH. Seeds drop from late September into the winter. Most seeds are dispersed by wind within short distances of the parent tree. Some dispersal by water also may occur. The best seedbed is in partial shade on moist litter or mineral soil. Stumps of sapling and pole-size green ash sprout readily. Cuttings made from 1-0 seedlings or 1-year-old sprouts root easily under greenhouse and field conditions. Cuttings may be planted horizontally under the soil or vertically with good results.

Cottonwood seed production starts when trees are 5 to 10 years old and good crops occur annually. Seeds disperse from June through mid-July via wind and water. Abundant deposits of seed occur along water courses as spring floodwaters recede. Cottonwood seedlings require very moist, exposed mineral soil, such as fresh silt deposits, and full sunlight for establishment. Artificial propagation normally involves use of cuttings from 1-year stem growth from nursery trees. These may or may not be rooted before outplanting.

To stimulate natural regeneration, clearcut all trees greater than 2 inches DBH. Tree seedlings present in the understory before harvest usually are not abundant, and if present, will probably include elm, maple, and possibly ash. A dormant season harvest encourages more stump sprouts, but should be planned to scarify the soil surface, providing exposed mineral soil for seed germination.

Consider planting within two years after harvest if natural regeneration is not adequate. Since planting is expensive, confine planting to the best sites and avoid locations that frequently flood. Prepare sites as follows:

1. Shear all residual woody vegetation near ground level.
2. Pile debris in windrows and burn it.
3. Rake the entire surface to collect any remaining vegetation.
4. Deeply disk and till the planting bed.

Silver maple and ash generally are established from seedlings. Cottonwood generally is established from cuttings. Plant at a 12-foot by 12-foot spacing as early as possible in the spring using genetically improved stock, if available. Planting with an auger will create better odds for survival than using a planting bar. Mechanical weeding will be necessary for the first two or three years.

Intermediate Treatments

Follow the guidelines below based on the dominant species in your stand.

The shade tolerance of silver maple ranges from tolerant on good sites to very intolerant on poor

sites. On upland soils, silver maple grows well but is highly intolerant of competing vegetation. In very dense stands a precommercial thinning and weeding of undesirable trees is recommended to encourage the growth of the most desirable trees. The first commercial thinning should occur when codominant trees average 8 to 10 inches DBH. Two or three more thinnings will be required every 7 to 15 years to sustain fast growth. Remove diseased trees and those of low vigor or poor form. Follow the crop-tree release method described in Chapter 5: Woodland Improvement Practices or the stocking chart for elm-ash-cottonwood in Appendix C-2 on page 208 to determine when and how much to thin. At final harvest most stands should have 120 to 130 square feet of basal area (roughly 50 high-quality trees) an acre of commercial species.

Green ash varies from intolerant to moderately tolerant of shade. Natural stands may have enough volume to allow commercial thinnings at 25 to 30 years. To ensure reasonable volume production and reduce epicormic branching in the remaining trees in the stand, do not reduce the basal area below 100 to 120 square feet an acre.

Cottonwood is very intolerant of shade. In natural stands, uneven spacing and size permit some trees to become dominant and natural thinning allows production of large trees. Under plantation conditions, and particularly when only clones with similar growth rates are used and all trees get off to a good start, stagnation can occur quickly. Spacing and the timing of thinning become critical under these conditions. Optimum growth of individual trees requires very wide, seemingly wasteful, spacing.

Pests and Diseases

Major insect pests in this type of forest are the emerald ash borer, forest tent caterpillar and cankerworms. The emerald ash borer continues to move westward across the Lake States. Follow state department of agriculture recommendations about handling stands that are infested with emerald ash borer and about moving ash wood. If there is an emerald ash borer infestation within 10 miles of your stand, harvest your ash trees as soon as possible to salvage their value and remove possible host trees. Chemical or microbial insecticides may be required to control defoliators. Major diseases include Dutch elm disease, ash yellows, and cytospora canker. Harvest commercial-size elms whenever possible to salvage their value before Dutch elm disease kills them. Retain elms during thinning only when no other desirable tree is available. Reduce canker damage by thinning to promote tree vigor, but be very careful to avoid damaging remaining trees.

Tamarack

Tamarack or eastern larch (Figure 6-16) is found in pure stands, but more commonly appears in mixed stands with black spruce, northern white-cedar, black ash, red maple, eastern white pine, or paper birch. Tamarack stands usually are even-aged.

Figure 6-16. Range of tamarack.

Products and Uses

Tamarack is used for pulp, poles, and lumber, although it has relatively minor economic importance. Red squirrel, snowshoe hare, and porcupine are found in tamarack stands. Tamaracks provide habitat for many songbirds and are critical habitat for the great gray owl and its small mammal prey species.

Site Conditions

Tamarack commonly grows on peatland where the organic soil or peat is more than 12 inches deep. It occurs on a wide range of peatlands, but is most characteristic of poor swamps where soil water is weakly enriched with mineral nutrients. The best sites are moist, well-drained loamy soils along streams, lakes, or swamps, and mineral soils with a shallow surface layer of organic matter. It grows well on upland sites, but is quickly eliminated by competition from more shade-tolerant species. Tamarack will not survive prolonged flooding. Site index curves for tamarack are shown in Appendix B-12 (see pg. 205).

Regeneration

The regeneration system recommended for tamarack stands is a combination of clearcut and seed-tree with natural seeding. Good seed years occur every 3 to 6 years starting when trees are about 40 years old. The best seedbed is a warm, moist mineral or organic soil with no brush, but a light cover of grass or other herbaceous vegetation. Hummocks of slow-growing sphagnum moss often make good seedbeds. Most seeds fall within 200 feet of the seed tree.

Harvest strips should be oriented perpendicular to the wind and may be up to 200 feet wide. After clearcutting the first strip, wait about 10 years or until the area is well stocked with seedlings, then clearcut a second strip adjacent to the first and on the windward side. Again wait until regeneration is established, then use the seed-tree method to cut the remaining strip. The seed-tree cut should leave about ten well-spaced dominant tamaracks an acre. Once the regeneration is established, harvest or kill the seed trees.

You may need to prepare the site following a harvest to ensure tamarack regeneration. Broadcast burn mixed species stands to remove slash. Since tamarack slash does not burn well, harvest pure tamarack stands by full-tree skidding to remove slash, then treat the brush with herbicides. Alternatively, you could pile and burn the slash or shear or chop the brush.

Tamarack seedlings need abundant light and constant moisture. Seedlings established under a fully stocked stand will not survive beyond about the sixth year. Early seedling losses are caused by damping-off fungus, drought, flooding, inadequate light, and snowshoe hares. Given enough light, tamarack is one of the fastest growing conifers on upland sites.

Intermediate Treatments

Thinning is economically feasible only on good sites when the objective is to produce poles or sawtimber. If a market exists for small products such as posts or pulpwood, make a commercial thinning as soon as the stand produces these products. Additional periodic thinnings are recommended up to 20 years before the end of the rotation. Each thinning should leave a basal area of 80 to 90 square feet an acre.

Pests and Diseases

The larch sawfly is a serious insect pest that can kill tamaracks after several years of defoliation. Chemical control may be required to manage sawfly populations Because there is no effective cultural control. Bark beetles can kill tamaracks that are stressed by defoliation or competition in densely stocked stands. Tamaracks also are susceptible to root and heart rots. Minimize rots by avoiding damage during intermediate cuttings. Porcupines can cause extensive damage by feeding on the bark of the main stem.

White Oak–Black Oak–Northern Red Oak

White oak, black oak, and northern red oak comprise the majority of stocking in this type, but any one of these species may dominate the type depending on site conditions (Figure 6-17). Other common associates are northern pin oak, bitternut hickory, shagbark hickory, pignut hickory (southern Michigan), yellow poplar (southern Michigan), sugar and red maples, white and green ash, American and red elm, and basswood. Occasionally black walnut, black cherry, American beech, and eastern hemlock may be present.

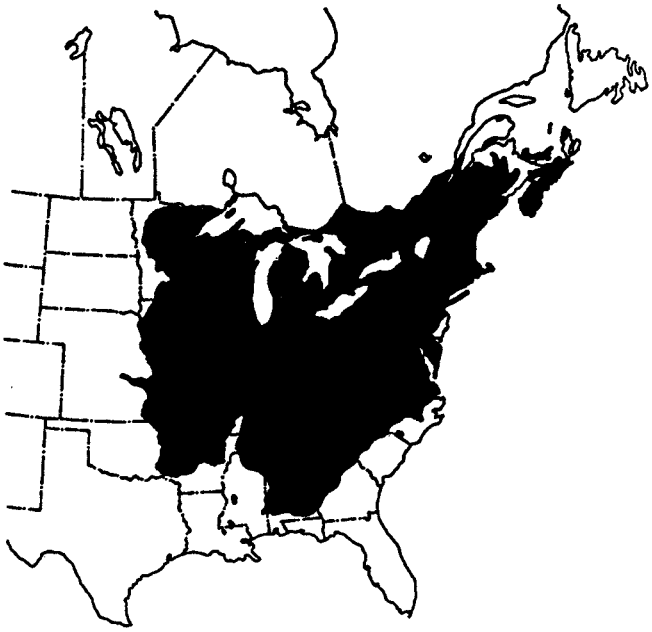

Figure 6-17. Range of northern red oak.

Products and Uses

Oak is valued in the manufacture of furniture, flooring, paneling, ties, and fuelwood. White oak also is used for barrel staves. Red oak usually is the most valuable species in this type for wood products.

Oak woodlands are home to many animals, including white-tailed deer, gray and fox squirrels, raccoon, opossum, red fox, bobcat, skunk, turkey, ruffed grouse, and many songbirds. Acorns are an important food for squirrels, deer, turkey, mice, voles, and other mammals and birds. Wildlife prefer white oak acorns, but will eat acorns from any oak species.

Site Conditions

Oaks grow on a variety of soils with texture varying from clay to loamy sands and on some soils that have a high content of rock fragments. Oaks may occur on all topographic positions from valley floors to narrow ridgetops and on all aspects. Red oak is most common on moist sites. White oak occurs over a range of moist to dry sites. Black oak is most abundant on drier sites. This type tends to be succeeded on moist sites by sugar maple, basswood, white ash, elms, beech, and other moisture demanding species. On drier sites, the type is stable.

Oaks grow best on north- and east-facing, gently sloping, lower slopes; in coves and deep ravines; and on well-drained valley floors where soils are at least 36 inches deep. Medium-quality sites have moderately deep soils (20 to 36 inches) on upper and middle slopes facing north and east. Oaks survive, but grow poorly, on narrow ridgetops or south- and west-facing steep, upper slopes where soil is less than 20 inches deep. Oaks survive better than most other tree species on dry sites, but they do not produce much merchantable timber on such sites. There is fierce competition among tree species on the best sites, so oaks are difficult to regenerate there.

Site index curves for northern red oak are in Appendix B-13 (see pg. 206).

Regeneration

These recommendations focus on regenerating northern red oak, which typically is the most valuable species in this type. Oaks may live for several hundred years, but for timber production on moderate to good sites, regenerate when the:

- Oaks are 80 to 120 years old and trees average 18 to 24 inches DBH,
- A stand is greatly understocked.
- Most trees are of poor quality or of undesirable species.

Oaks commonly reproduce from acorns. Red oaks produce good acorn crops at 2- to 5-year intervals beginning about age 50. The best seed producers are dominant or codominant trees with large, uncrowded crowns. Acorns drop in the fall. White oak acorns germinate soon after falling, but red oak acorns germinate the following spring. Insects, mammals and birds can eat or damage more than 80 percent of the acorn crop in most years and nearly all of the crop in very poor seed years. Gravity and the caching activities of squirrels and mice disperse seeds only short distances. Birds distribute acorns over longer distances, but such dispersal is not reliable for regeneration. The best germination occurs when acorns are in contact with or buried in mineral soil under a light covering of leaves.

Northern red, black, and white oaks are intermediate in shade tolerance, although white oaks are more tolerant than the other two. In stands with a dense understory or overstory, there will be few oaks in the understory.

Natural oak regeneration is most reliable where there is plenty of advance regeneration. The number of oak seedlings needed to successfully stock the next stand depends on seedling size before the harvest. The larger the seedlings, the more likely they are to survive to harvestable size.

Recommended	
Seedling Height (feet)	**Seedlings per Acre**
<1	**15,435**
1 – 2	**3,087**
2 – 4	**1,029**
>4	**514**

Stands that are well-stocked with advance regeneration and that have relatively little competition from undesirable understory trees, shrubs, or other vegetation may be clearcut. Such conditions are more likely to occur on moderately dry sites. Clearcut at least one-half acre and preferably at least two acres; otherwise, shade from the surrounding timber will suppress oak seedlings. For regeneration purposes there is no maximum size for clearcuts, so long as there is good advance regeneration.

If there is a seed source present, but few oak seedlings, the problem often is too much shade. Acorns may germinate and the seedlings may survive for several years beneath heavy shade, but advance oak regeneration will not accumulate over a long period. Northern red oak reaches maximum photosynthesis at about 30 percent of full sunlight.

To reduce shade produced by an understory of shade-tolerant hardwood trees, shrubs, or ferns, cut or treat vegetation with herbicide, depending on the species to be controlled. If dense shade is produced by a high canopy, also conduct a shelterwood harvest, leaving 75 to 85 percent crown cover in species and individual trees that you want to have provide seed for the next generation. Harvest carefully to avoid damaging the remaining timber.

Following a shelterwood harvest and understory removal, wait several years to be sure that a satisfactory number of oak seedlings are present, then clearcut. If the oaks take more than five years to regenerate, apply additional understory control as needed. To protect advance reproduction and encourage stump sprouting, clearcut when the ground is frozen. If you need to harvest in other seasons, restrict log skidding to narrow corridors to reduce the soil disturbance that favors germination of undesirable species.

An alternative to the shelterwood harvest is to wait until there is a good acorn crop, then clearcut and disturb the soil after the acorns drop but before the ground freezes. Soil disturbance helps to bury the acorns and uproot competing vegetation.

Because of the risk and possible delay involved when relying on natural regeneration, you may want to plant seedlings after a shelterwood or clearcut. Planting also enables you to supplement natural regeneration, to use genetically superior stock when it is available, and to choose the species. Control undesirable trees and shrubs by cutting, bulldozing, or treating with herbicide in the fall. Harvest by shelterwood or clearcut, then plant oak seedlings the next spring. On forest sites, plant oaks 20 to 25 feet apart, allowing other trees to provide the necessary stand density. In open fields, plant trees 5 to 8 feet apart within rows and 10 to 12 feet apart between rows.

The best oak seedlings have a fibrous root system and a stem at least 3/8-inch in diameter. If large seedlings are difficult to handle during the planting operation, just before planting clip the tops of the seedlings—and the roots, if necessary—leaving each about 8 inches long. Plant 200 to 800 seedlings an acre, depending on their size and the amount of advance reproduction already in the stand. Control weeds around the oak seedlings for up to three years. Herbicides are often effective and economical for weed control.

Oaks also reproduce from stump sprouts following a harvest. Sprouting frequency declines as tree diameter and age increase. Northern red oaks sprout more frequently than white and black oaks. New sprouts grow rapidly and are usually straight and well formed, especially if they arise close to ground level.

Intermediate Treatments

Control undesirable tree species that compete with crop trees when the stand height averages at least 25 feet (when the trees are 10 to 20 years old). When growing trees for timber production, thin stump sprouts when they are about 10 years old (but no more than 3 inches in diameter). Leave one or two dominant sprouts that have good form and arise within 6 inches of the ground. When managing oaks for timber, keep stands fairly dense until the bottom 20 to 25 feet of the stems are essentially free of live branches. This generally will occur when trees are 40 to 50 feet tall (30 to 45 years). At this stage, thin stands to stimulate the stem diameter growth of crop trees. Release no more than 100 crop trees an acre. Select crop trees that are 20 to 25 feet apart. Provide at least 5 feet of clear space around three sides of the crop tree crowns. As an alternative, follow the stocking charts for upland central hardwoods in Appendix C-7 on page 211. Repeat thinning every 15 to 20 years, but stop thinning when stands reach about 60 years. Pruning will improve wood quality and may be needed if the stand density is not high enough to cause natural pruning.

Pests and Diseases

The most destructive defoliating insect attacking oaks is the invasive gypsy moth. It repeatedly defoliates trees and has killed oaks throughout the northeastern United States. It is present in Michigan and Wisconsin and is moving westward. Northern red oak can recover from a single defoliation but may be weakened enough for some disease or other insects to kill them. Several other defoliators occasionally cause serious damage or weaken trees. To reduce damage from defoliators, maintain stand vigor, consider spraying high value stands with an insecticide if repeated defoliations occur, and manage stands for species diversity.

Minimize chestnut borer damage by maintaining vigorous stands. Specifically, in upland stands with site indexes of less than 65 (see Appendix B-13 on pg. 206), maintain basal areas at less than 120 square feet an acre in stands with trees averaging 7 to 15 inches DBH, and at less than 100 square feet an acre in stands averaging more than 15 inches DBH. Avoid thinning for five years after a serious drought or defoliation.

Oak wilt is the most serious disease that affects oak trees. To minimize infections, do not thin or prune oaks from mid-April through mid-July, when fungal spores are present and can be transported by picnic beetles to fresh wounds. Dormant season operations are best because spores are not present and the trees are not susceptible to infection. Since oak wilt commonly spreads through root grafts between neighboring oaks, surround valuable oak stands in areas with a high oak wilt hazard with a 100-foot buffer of an alternate species. If trees become infected, harvest them before the following spring. Use a trenching machine or vibratory plow to break the root grafts through which the disease spreads. Trench placement and depth are critical. Consult a forester for advice before trenching. Left untreated, oak wilt will spread through the stand until it kills all the red oaks. White and bur oaks are not commonly affected by oak wilt.

Minimize damage from shoestring root rot by maintaining vigorous, well-stocked stands.