NORTHEASTERN AND NORTH CENTRAL FOREST TYPES AND THEIR MANAGEMENT

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ABSTRACT.--A brief background is given of the forests of the north-central and northeastern United States. Then, the major forest types, typical timber management objectives, and common silvicultural practices used in these forests are described.

Management of forests of the north-central and northeastern United States for wood products affects a wide variety of habitats for nongame birds. Therefore, a familiarity with the major forest types and how they are managed is desirable to fully understand these forests as habitats for nongame birds. This report briefly outlines the major forest types, the principal forest products, and the typical silvicultural practices of this region.

BAILEY'S ECOREGION CLASSIFICATION

Because many of the forest types occur over the entire area--for example, northern hardwoods are found from Minnesota to the east coast--I will use Bailey's (1978) hierarchial classification system (ECOREGION) to characterize the region in broader, more generalized terms before describing the types. In Bailey's system, the north-central and northeastern United States are classified within the Humid Temperate Domain (fig. 1); a mid-latitude zone where the presence of both tropical and polar air masses cause large seasonal changes in temperature and precipitation. Forests are a mixture of evergreen needleleaf and deciduous broadleaf trees (Bailey 1978). The Domain is subdivided into two areas--the Warm Continental and the Hot Continental.

In the eastern United States, the Warm Continental Division is synonomous with the Laurentian Mixed Forest Province. This Province occurs between latitudes 40° and 55° North and extends from the continental interior to the east coast. It is made up of the north-central Lake-Swamp-Moranic Plains and the Adirondack-New England Highland landforms. The entire area was glaciated during the Pleistocene and thus lakes, poorly drained depressions, moranic hills, drumlins, eskers, and outwash plains are common. Elevations within the province are generally from sea level to 4,000 feet with a few peaks of above 5,000 feet. Rolling hills of low relief characterizes most of the area, but the mountains of the Adirondack-New England Highlands have reliefs of 1,000 to 3,000 feet. Winters are cold and moderately long and snow cover is usually present all winter. Summers are warm--more than 120 days of temperature above 50°F.--but the growing season is short and the frost-free period is from 100 to 140 days. Precipitation ranges from 24 to 45 inches with a maximum in the summer and no dry seasons (Bailey 1978).

The vegetation of the Province is transitional between the boreal forests to the north and the deciduous forests to the south and is composed of stands of mixed coniferous-deciduous species, or mostly pure deciduous stands on favorable sites, and mostly pure coniferous stands on less favorable sites (Bailey 1978). The pines and many of the deciduous species are pioneers that follow fire or abandonment of cleared land. Four plant association sections are recognized within the province: Spruce-Fir, Northern Hardwoods-Fir, Northern Hardwoods, and Northern Hardwoods-Spruce (figs. 1 and 2).

The Hot Continental Division lies immediately adjacent to the Warm Continental Division. The boundary between the two is the 72°F. warmest-month isotherm. The landforms comprising the Eastern Deciduous Forest Province of this Division are the East-central Drift and Lakebed Flats, the Eastern Interior Uplands and Basins, and the Appalachian Highlands. Only the northern parts of the Province were glaciated. Elevations range from sea level to 2,500 feet with a few peaks above 4,500 feet. Most of the area is rolling and has low relief, but in the Appalachian Highlands relief is as much as 3,000 feet. The climate is one of cool winters and hot summers with 35 to 60 inches of annual precipitation and a maximum in summer. The vegetation is primarily deciduous broadleaf--northern hardwoods or oaks--and conifers at higher elevations. On low, wet areas, the vegetation is primarily bottomland hardwoods and spruce. The plant association sections that make up the Province are the Maple-Basswood and Oak Savanna, Beech-Maple, Mixed Mesophytic, Appalachian Oak, and Oak-Hickory (figs. 1 and 2).

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DOMAIN (2) HUMID TEMPERATE

DIVISION (21) WARM CONTINENTAL

PROVINCE (211) LAURENTIAN MIXED FOREST

SECTION (2111) Spruce-Fir

(2112) Northern Hardwoods-Fir

(2113) Northern Hardwoods

(2114) Northern Hardwoods-Spruce

DIVISION (22) HOT CONTINENTAL

PROVINCE (211) EASTERN DECIDUOUS FOREST

SECTION (2211) Mixed Mesophytic

(2212) Beech-Maple

(2213) Maple-Basswood and Oak Savanna

(2214) Appalachian Oak

(2215) Oak-Hickory

Figure 1.--*Ecoregion classification of northeastern United States forests (Bailey 1978)*

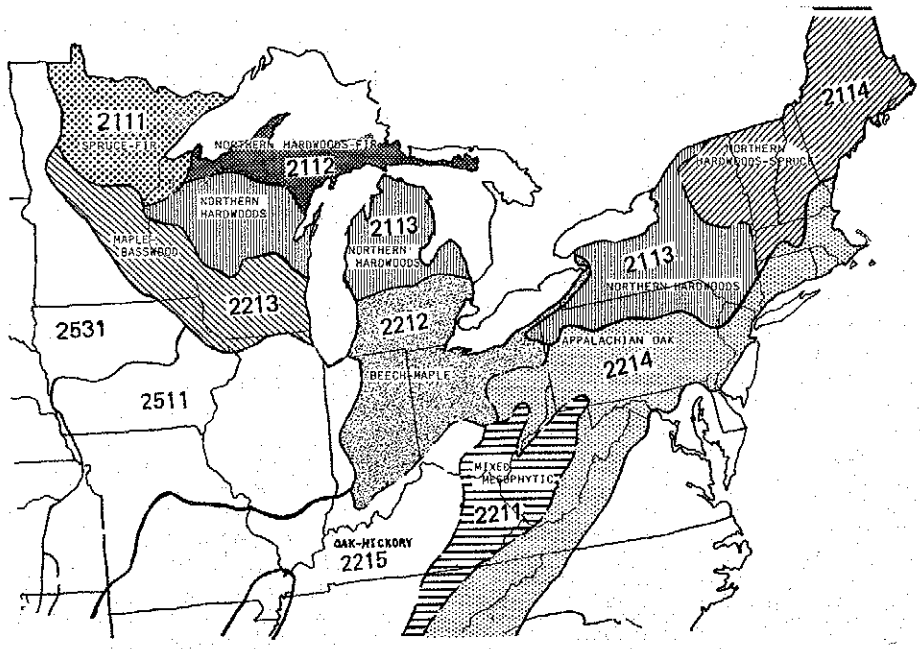

Figure 2.--*Forest types of the north-central and northeastern United States according to Bailey's 1978 Ecoregion classification.*

MANAGEMENT SYSTEMS

Forest land is managed primarily by cover type and the types are based on the majority of trees in the stand. Those typically listed for the north-central region are jack pine, red pine, aspen, northern hardwoods, and black spruce. The principal northeastern types are spruce-fir, eastern white pine, northern hardwoods, cherry-maple, and Appalachian mixed hardwoods. Other types that are important in one or both regions are northern white-cedar, cove hardwoods, oak-pine, and lowland (bottomland) hardwoods.

Many of the forest types in the north-central and northeast are dominated by shade-intolerant species characteristic of early succession, and thus lend themselves best to even-aged silvicultural systems. Under even-aged management the goal is to regenerate and culture stands that are about the same age (all desired trees receive the same amount of direct sunlight during regeneration and growth of the stand). Even-aged management can be a clearcut at rotation age followed by regeneration of the stand through direct seeding, as is common for jack pine; through planting, as is common for red pine; or through allowing resprouting, as is common for aspen. Even-aged management can also include leaving shelterwood or seed trees when harvesting near the end of a rotation to provide natural regeneration, followed by removal of the shelterwood trees or seed trees after the new stand is established.

Even-aged silvicultural practices range from a "let-grow" policy to intensive managemant where both noncommercial and commercial thinnings are made prior to final harvest (Ohmann *et al.* 1978). The intensity of management depends on species composition, stand condition, site quality, markets, and management objectives for resources other than wood products.

Forest types composed of tolerant species (sugar maple, beech, spruce, or fir) are often managed under uneven-aged (all-aged) systems. The usual harvest method under this system is to periodically remove selected mature and immature trees either singly or in small groups. Regeneration occurs almost continuously, thus creating an uneven-aged stand of trees of different ages or sizes intermingled either singly or in small groups. The single tree selection method in mixed species stands leads to an increase in the proportion of the more shade-tolerant species in the stand. The group selection method can be used to maintain a higher proportion of less shade-tolerant species.

FOREST TYPES

Presented below are the principal forest cover types of the north-central and northeastern regions, the Ecoregion and Kuchler (1964) plant associations in which they may occur, the typical timber products desired from them, and the usual silvicultural practices used to meet the timber objectives. More detailed information about each type can be found in the management guides from which the data was summarized.

Jack Pine

The jack pine (Benzie 1977a) type occurs primarily in the north-central region where it occupies about 2.5 million acres. It is found in the Spruce-Fir, Northern Hardwoods-Fir, and the Northern Hardwoods Ecoregion Sections (fig. 2) and in Kuchler's Great Lakes Pine Forest type.

Jack pine grows in both pure and mixed stands. Common associates in mixed stands are red and eastern white pine, aspens, white birch, several oaks (mainly northern red oak and northern pin oak), and spruce-balsam fir mixtures. The type is usually found on level to gently rolling sand plains of glacial outwash, fluvial, or lacustrine origin. It also grows on eskers, sand dunes, rock outcrops, ridges, and glacial lake beds and beaches.

Jack pine is a small, short-lived species that establishes readily on recently burned areas, especially on exposed sand sites. It is less shade-tolerant than any of its principal associates except quaking aspen and white birch. Thus, jack pine is a temporary type that on better sites is replaced by more shade-tolerant species when natural succession is not interrupted by fire. On poor sites, jack pine is more permanent and usually grows in pure stands but may be mixed with northern pin oak. The poorest jack pine sites are largely free of shrubs, the medium sites are characterized by ericaceous low shrubs, and the better sites often have a dense undergrowth of tall shrubs.

Jack pine is one of the few species that is generally not re-established where it grows best. Typical timber management objectives are to maintain the type where it is the best-suited species and to replace it at the end of rotation with more productive species (such as red pine) on sites where it is not the best-suited species. Most stands are managed for pulpwood, but stands on the best sites (SI=60+) may be managed for poles or small sawtimber with intermediate thinning.

The preferred silvicultural practice for the type is even-aged management with a regeneration harvest through clearcutting. This is followed by preparing the site through mechanical scarification, chemical control of vegetation, or prescribed burning. Then, the site is planted or seeded (branches bearing serotinous cones are scattered over the area or seeds are dispersed directly on the mineral soil). Jack pine is occasionally regenerated by the seed-tree system if good quality seed trees are available and prescribed burning can be used to prepare the site. Commercial rotation ages are typically 40 to 50 years for pulpwood and on good sites, 60 to 70 years for poles and small sawtimber.

Red Pine

Red pine (Benzie 1977b) occupies about 1 million acres in the north-central region and less than 0.5 million acres in the northeastern region. Although the area of natural red pine forest is small in both regions, it has been greatly expanded by planting. It is found in the Spruce-Fir, Northern Hardwoods-Fir, Northern Hardwoods, and Northern Hardwoods-Spruce Ecoregion Sections (fig. 2) and in Kuchler's Great Lakes Pine Forest type. Naturally occurring red pine is most common on level to gently rolling topography underlain by fine to loamy sands or on low ridges adjacent to lakes and swamps. It grows best on moist, well-drained soils but can withstand moderate drought. In the north-central region, red pine grows in both pure and mixed stands. Associated species on coarse, dry soils are jack pine, aspen, white birch, and northern pin oak. On fine to loamy sands, associates include eastern white pine, red maple, northern red oak, and white spruce-balsam fir mixtures.

Typically, red pine stands are managed intensively to produce pulpwood, posts, poles, cabin logs, and small sawtimber from intermediate thinnings, and high-quality sawtimber and veneer logs from the final crop.

The preferred silivicultural practice is even-aged management with periodic thinnings and a final regeneration harvest through clearcutting. This is followed by preparing the site through mechanical scarification, chemical control of vegetation, or prescribed burning and planting seedlings. Red pine is usually released from competing vegetation by the end of the third growing season. Commercial rotation ages range from 60 years (on best sites with thinning) to 120 years.

White Pine

Eastern white pine (Little *et al.* 1973), the mainstay of the early logging era, is now of minor importance as a timber species in the north-central region. Throughout most of the Lake States, it is threatened by white pine blister rust. Thus, white pine is infrequently planted and planting will not widely increase until rust-resistant stock becomes readily available. Naturally occurring white pine is found in scattered stands throughout the north-central region but is most frequently found as a component of other types--as a super-canopy, as scattered individuals, or as a dominant or codominant component of red pine stands. In the north-central region it occurs in the Spruce-Fir, Northern Hardwoods-Fir, and Northern Hardwoods Ecoregion Sections (fig. 2) and in Kuchler's Great Lakes Pine Forest type. White pine remains an important forest type in the northeastern region where it covers about 7 million acres. It occurs in the Northern Hardwood-Spruce and Appalachian Oak Ecoregion Sections (fig. 2). In the northeast, white pine is often a pioneer species in abandoned fields and pastures. Optimum development is on moist, deep loams or on sandy loams of lower slopes, but it also is able to compete on upper slopes and ridgetops. Common associates of white pine include 9 conifers and at least 18 hardwood species. Densely stocked pure or nearly pure stands of white pine in the north-central region have a poorly developed tall shrub layer, and a low shrub layer that is more prominant than the sparse herbaceous ground cover.

White pine is not well suited for pulpwood, so sawtimber is the major timber management objective (other than Christmas trees). Small wood products can be derived from thinnings, tops, and limbs.

The preferred silvicultural practice is even-aged management with an intermediate thinning and a regeneration harvest through clearcutting followed by site preparation and planting. If a final heavy thinning is made during a good seed year about 10 years prior to clearcutting, good natural regeneration can be expected and advanced regeneration will be available at the final harvest. Release from competing vegetation will usually be necessary. The white pine type is also often harvested and regenerated through a two-stage shelterwood system. Commercial rotation age is from 80 to 120 years.

Spruce-fir

The spruce-fir (Gibbs 1973) type occupies nearly 3 million acres in the north-central region and occurs in the Spruce-Fir, Northern Hardwoods-Fir Ecoregion Sections (fig. 2) and in Kuchler's Great Lakes Spruce-Fir Forest type. In the Lake States, balsam fir is typically more abundant within the type than is white spruce. Spruce-fir is considered the climax forest type for a major part of the Lake States occupied by aspen, birch, and associated conifer forests (Ohmann and Ream 1971). In the

north-central region, old-growth stands have various mixtures of balsam fir, white birch, and white spruce. These stands may also contain some black spruce, aspen, and northern white-cedar, and a few black ash, red maple, and balsam poplar. If succession is less advanced, white, red, and jack pine may also by associated with the type. Sometimes, small (usually less than 10 acres), scattered stands of pure fir will originate after fire, windstorms, or epidemics of spruce budworm.

In the Lake States balsam fir occurs also as an understory strata within stands of aspen, white birch, jack pine, white pine, and occasionally red pine. In the natural course of succession, these areas will become spruce-fir. Much of the spruce-fir type within the north-central region originated in this manner, particularly on areas that were undisturbed for many years. North-central region spruce-fir stands typically have a well-developed tall shrub layer, a poorly developed low shrub layer, and a ground cover of mosses that predominate over herbs.

The northeastern region spruce-fir type occurs in the Northern Hardwoods-Spruce Ecoregion Sections(fig. 2) and in Kuchler's Northeastern Spruce-Fir Forest type. Red spruce, white spruce, and balsam fir are the principal species in this region. The type covers nearly 11 million acres in New England and New York. Depending on site conditions, stands may contain only the spruces and fir or spruce-fir in various combinations with other conifers and hardwoods. These other conifers include northern white-cedar, eastern hemlock, eastern white pine, and tamarack. The hardwoods include red maple, paper birch, aspen, white ash, American beech, sugar maple, and yellow birch. Red spruce, white spruce, and balsam fir will grow on a variety of soils, including those that are poorly drained.

In both the Lake States and New England regions, the typical timber objective is to manage the better sites for balsam fir pulpwood and white or red spruce sawtimber. In the central Appalachians, red spruce on good sites is managed for large sawtimber and on poor sites is either managed for pulpwood or reserved for recreation and aesthetic purposes.

The preferred silvicultural practice is even-aged management with regeneration harvest by clearcutting narrow strips or small patches so adjacent areas can shade advance regeneration or serve as a seed source if advance regeneration is not present at harvest. Commercial rotation age is about 70 years for pulpwood and 120 to 150 years for sawtimber. Uneven-aged management can be used in all-aged stands or to achieve an all-aged structure. In these cases, selection cutting of single trees or small groups of trees is done every 5 to 20 years.

Black Spruce

The black spruce (Johnston 1977a) forest type occupies about 2.1 million acres in the north-central region. Sixty-eight percent of this acreage is in Minnesota, and the remainder is in the northern parts of Michigan and Wisconsin. The black spruce type is a major source of pulpwood in northern Minnesota. Christmas trees are harvested on a limited scale on sites too poor for growing pulpwood. The type also occurs as scattered stands on low areas within the northeastern region. Black spruce occurs in the Spruce-Fir, Northern Hardwoods-Fir, Northern Hardwoods-Spruce Ecoregion Sections (fig. 2) and in Kuchler's Conifer Bog Forest type.

Black spruce grows in both pure and mixed stands; in some mixed stands it predominates and in others it is important but not predominant--mixed swamp conifer, upland white spruce-balsam fir, and jack pine types.

The black spruce type is found on organic soil in both regions and on mineral soil in the Lake States. Extensive areas of organic soil are found on gently sloping glacial lakebeds or smaller filled lakes associated with the Laurentian Shield, pitted outwash plains, and morainic areas. On both lakebed and filled-lake sites, the growth rate of black spruce is related to the surrounding ground water flow system. The best sites occur where the soil water is continuous with the regional ground water system and thus is enriched with nutrients flowing from mineral soil areas. The poorest sites occur where the soil water is "perched" above and therefore separated from this regional system. The fertility of these latter sites depends mainly on precipitation, which is low in nutrients.

The black spruce type is common on mineral soil only on the Laurentian Shield area of northeastern Minnesota and in a few isolated areas of Upper Michigan. In these areas black spruce grows on gravelly and bouldery loam and on shallow soil over bedrock. It is usually mixed with other species--jack pine, aspen, and balsam fir--but occasionally forms a pure type. Growth is best where the slope is gentle and moisture is plentiful, either from a shallow water table or seepage. South of the Shield, black spruce is occasionally found on sandy soil with a high water table.

Black spruce stands on the best organic soil sites typically have a dense understory of tall shrubs and stands on medium to poor sites have only a few low shrubs and many sphagnum and feather mosses. Pure black spruce stands on mineral soils often have a poorly developed shrub and herb component and an extremely well-developed carpet of moss (Ohmann and Ream 1971).

The typical timber objective for the type is to manage for a sustained yield of pulpwood on good sites (SI >25) and for Christmas trees on poor sites.

The preferred silvicultural practice is even-aged management with a regeneration harvest through clearcutting, followed by broadcast burning to prepare the site for seeding. Cut strips up to 4 chains wide can be naturally seeded but large patches must be direct seeded. Burning of slash is recommended for all brushy sites, sites with heavy slash, and sites containing dwarf mistletoe. Release from competing shrubs and hardwoods on good sites is usually necessary. Commercial rotation age is from 60 to 160 years depending on stand basal area and stem density. On poor sites, Christmas trees can be grown under uneven-aged management with group selection cutting about every 10 years.

Northern White-cedar

The white-cedar (Johnston 1977b) type occurs in both the north-central and northeastern regions and is found in the Spruce-Fir, Northern Hardwoods-Fir, Northern Hardwoods, and Northern Hardwoods-Spruce Ecoregion Sections (fig. 2) and in Kuchler's Conifer Bog Forest type. The type is most common in the north-central region. It occupies 1.9 million acres in the Lake States, most of it (62 percent of the acreage) in Michigan. The remainder occurs in the northern parts of Minnesota and Wisconsin.

Northern white-cedar grows in both pure and mixed stands. In some mixed stands it predominates and in others it is important but not predominant, such as in the mixed swamp conifer, black spruce, tamarack, and black ash-American elm-red maple types.

The northern white-cedar type is found primarily on organic soils in the Lake States, but is also occurs on mineral soils, mainly on seepage areas and limestone uplands.

Organic soil origin, degree of decomposition, and drainage in the upper horizons are good guides to site productivity. The best soils are neutral or slightly alkaline and contain moderately-to well-decomposed organic matter derived from woody plants or sedges. However, the upper 4 inches on these sites may be poorly decomposed sphagnum or other mosses. The best sites have moving soil water and are usually near streams or other drainageways. In contrast, the poorest sites have poorly decomposed acid soil, derived from plants such as sphagnum moss, throughout the entire root zone. These sites have little water movement and are often far from drainageways.

Typically, the tall shrub layer is well-developed, and the species composition varies depending on whether the stand is on organic or mineral soil. The low shrub layer and the herb layer are usually poorly developed. Mosses predominate over herbs in the latter, especially on organic soil.

The typical timber management objective is a sustained yield of posts, poles, and sawtimber. Sites less than SI=25 should be managed extensively for small posts.

The preferred silvicultural practic is even-aged management with regeneration harvest through clearcutting narrow strips or small patches and relying on natural seeding (large clearcut patches will require direct seeding). A combination of clearcut and shelterwood (alternate or progressive strips) can also be used. Broadcast burning of slash, except where shelterwood trees are present or where residual stems are to be saved, will help ensure regeneration. Commercial rotation age varies with site and management objective: 100 to 140 years on poor sites; 70 to 90 years for posts on good sites; and 110 to 140 years for sawtimber on good sites.

Aspen

Aspen (Perala 1977) covers about 13 million acres and is the largest and most widely distributed of the forest types in the north-central region. The type also occurs in the northeastern region. It can be found within the Spruce-Fir, Northern Hardwoods-Fir, Northern Hardwoods, and Northern Hardwoods-Spruce Ecoregion Sections (fig. 2) and in Kuchler's Great Lakes Pine Forest, Great Lakes Spruce-Fir Forest, Northeastern Spruce-Fir Forest, and the Northern Hardwoods Forest types. The dominant species is quaking aspen, which is a small to medium-sized tree that can grow in essentially pure stands but usually is found with other species. Common associates are bigtooth aspen, white birch, northern red oak, red maple, balsam poplar, jack pine, balsam fir, spruce, and northern white-cedar.

Aspen occupies diverse soils and sites, and its growth rate varies with soil fertility and available moisture. Aspen has persisted in natural stands largely because of fire. Even where it is a minor component of the stand, aspen's ability to produce abundant root suckers often enables it to become the dominant species after logging or fire. If aspen is already dominant, it easily re-establishes itself after logging, especially when cutting is followed by fire or similar treatments to kill back all vegetation.

Because aspen cannot reproduce successfully under its own shade, it is replaced by other

species when natural ecological succession is not interrupted by fires, logging, or windstorms. On dry sites, aspen is succeeded by red maple or oaks. On moist, fertile soils, aspen is followed by balsam fir, white or red spruce, white pine, or northern hardwoods. On wet sites aspen is succeeded by balsam fir, black spruce, or northern white-cedar.

Aspen stands typically contain well-developed shrub and herb layers. Plant species diversity is usually greater in this type than in any of its associated conifer forest types.

Timber management objectives vary with site. For most stands the objective is pulpwood. Good sites (SI>80) can be managed to produce veneer bolts and sawtimber. Poor sites (SI<50) can produce fiber through whole-tree utilization and chipping but can be converted to conifers or other hardwoods at the end of the rotation.

The preferred silvicultural practice is even-aged management with a regeneration harvest through clearcutting followed by natural vegetative sprouting. Clearcuts should be larger than 2 acres. Aspen stands with a northern hardwood understory can be regenerated by clearcutting or can be converted to northern hardwoods by using the shelterwood or selection cutting systems. Commercial rotation age is 35 to 45 years for chipping or pulpwood and 50 to 60 years for veneer bolts and sawtimber.

Northern Hardwoods

The northern hardwood (Tubbs 1977, Filip and Leak 1973) forests cover about 10 million acres in the north-central region and about 15 million acres in the northeastern region. The type can be found in the Northern Hardwoods-Fir, Northern Hardwoods, Northern Hardwoods-Spruce, Maple-Basswood, and Beech-Maple Ecoregion Sections (fig. 2) and in Kuchler's Maple-Basswood, Northern Hardwoods, Northern Hardwood-Fir, and Beech-Maple forest types. The type varies in composition and density depending on soil drainage, past cutting practices, and fire. Characteristic species are sugar maple, American beech, yellow birch, and eastern hemlock. In places basswood, paper birch, white ash, red maple, American elm, and eastern white pine are important associates. On well-drained upland loamy soils in the north-central region, sugar maple is the dominant species and beech, yellow birch, or basswood are the codominant species. On poorly drained sites, hemlock and yellow birch are dominant in the type.

In the northeastern region northern hardwood forests are found up to elevations of about 2,000 feet on rolling or mountainous land. The most productive soils are deep and well- to moderately-well drained.

Typical timber objectives are to manage for high-quality veneer and saw logs where species composition, age distribution, and site productivity allow. Other, less suitable stands are usually managed for pulpwood.

If the objective is to promote composition and yield of the more valuable, less tolerant species (primarily birches), the preferred silvicultural practice is even-aged management with a regeneration harvest through some form of clearcutting and site preparation or a shelterwood cut combined with site scarification and removal of undesirable advanced regeneration. Commercial rotation ranges from 50 to 120 years depending on site, management objective, and intensity of management. If the objective is to promote tolerant species (sugar maple, beech, hemlock, and spruce), uneven-aged management is used with regeneration of the type through selection cutting of individual trees or small groups. Adequate advanced regeneration is almost always present. Periodic cutting will increase composition and yield of desirable trees. Cutting cycles should be about 8 to 12 years in the Lake States and 10 to 20 years in the Northeast.

Cherry-maple

The cherry-maple (Marquis 1973) or Allegheny hardwood type covers about 12 million acres and is a pioneer forest type found within the northeastern region on the Allegheny Plateau of Pennsylvania and New York. It occurs in the Mixed Mesophytic and Beech-Maple Ecoregion Sections (fig. 2) and in Kuchler's Mixed Mesophytic Forest type. It owes its origin to the lumbering and fires of the 1890 to 1920 era in the vast hemlock-white pine-northern hardwoods region of the eastern deciduous forest.

The type is composed primarily of black cherry, red maple, and sugar maple, and common associates are white ash, yellow and sweet birch, American beech, and eastern hemlock. Within this type, black cherry is by far the most valuable species for timber production. Although black cherry grows over a wide geographic area in the eastern United States, it is much more abundant in the Allegheny hardwood area than elsewhere. Ash and maple are two other important timber species of this type.

Because the type occurs on fair to excellent sites, the typical timber objective is to manage for saw and veneer logs. The better the site, the more intensive the management that is economically feasible. On some fair sites, small wood products are the most typical objective (Trimble *et al.* 1974).

When the opportunity exists to manage for the more valuable black cherry and white ash, the preferred silvicultural practice is

even-aged management with intermediate thinning at about 30 years and a final regeneration harvest through clearcutting. Commercial rotation age is between 60 and 135 years. When the opportunity for cherry and ash are poor and sugar maple is the best alternative, uneven-aged management with selection cutting of individual trees or small groups of trees is recommended because sufficient advanced maple regeneration is almost always present.

Cove Hardwoods

The cove hardwoods (Trimble 1973), also known as the Appalachian mixed hardwoods, is the most productive hardwood type of the northeastern region. It occurs in the Mixed Mesophytic Ecoregion Section (fig. 2) and in Kuchler's Mixed Mesophytic Forest type. The type is found in the coves and on the moist slopes of the central and southern Appalachian Mountains and adjacent portions of the Allegheny and Cumberland Plateaus.

Cove hardwoods are highly productive and usually occupy good to excellent sites. Soils on these sites are normally deep, medium textured, and well drained and annual precipitation is ample and well-distributed throughout the year. On these rich sites, major species are long lived and can grow to very large sizes.

Stands are characterized by a great diversity of dominant and subdominant species. The species and their proportions vary considerably because of differing past treatments or natural disturbances on sites of different quality, aspect, elevation, and latitude. Species composition ranges from almost pure northern red oak to pure yellow-poplar but generally is a mixture that contains 20 or more commercial species. Important components are yellow-poplar, northern red oak, sugar and red maples, white oak, American beech, white ash, American basswood, black cherry, cucumbertree, sweet and yellow birches, hickories, yellow buckeye, and black locust. Many other species occur occasionally, including a few conifers--eastern white pine, red spruce, and eastern hemlock. On good sites at high elevations, the type merges with northern hardwood-black cherry mixtures. On dry sites with shallow soils, the type gives way to oak-hickory.

Because the type grows on the best sites and is the most profitable timber type in the northeast, management objectives are high-quality veneer and saw logs, and small wood products from thinnings, tops, and limbs.

The preferred silvicultural practice is even-aged management with intermediate thinnings and a final regeneration harvest through clearcutting to produce the most desirable mix of species in the new stand. Regeneration for the new stand comes from (1) sprouting from cut trees, (2) advanced regeneration of tolerant and intermediately-tolerant species, and (3) germinating seed, which was stored in the forest floor, from the intolerant yellow-poplar and black cherry. Final harvest rotation may be as short as 60 to 70 years with a heavy thinning schedule and control of tolerant understory at harvest. More typical rotations are from 75 to 105 years. Uneven-aged management through selection cutting of small groups of trees is possible but less desirable because it results in an increase of the less valuable maple and beech.

Oak-Pine

The oak-pine (Trimble *et al.* 1974) type occurs in the northeastern region as part of the Appalachian mixed hardwoods forest at elevations below 3,000 feet. It is found within the Appalachian Oak Ecoregion Section (fig. 2) and in Kuchler's Appalachian Oak Forest type. The five widely-distributed upland oaks in this type are white, northern red, black, scarlet, and chestnut. Although less abundant, the hickories are consistent stand components. Other associates are beech, red maple, sassafras, and sweet birch. Oaks are associated with white pine and pitch pine in parts of the region and with the hard pines in the western and southern parts of the central Appalachians. Oak stands commonly have a poorly developed herb layer and a well-developed shrub/vine strata.

On fair oak sites, management is typically for saw logs (sometimes pulpwood), and small wood products from thinnings, tops, and limbs. On poor oak sites (SI=45 to 54) pulpwood is the usual objective but these sites should probably be converted to pine at the end of the rotation. The management objective for pine is to grow it in pure stands for pulpwood.

The preferred silvicultural practice on fair oak sites is even-aged management with intermediate thinning at 30 to 40 years and a final regeneration harvest through clearcutting if advanced oak regeneration is present. Regeneration of the stand through shelterwood cutting is recommended if no oak advanced regeneration is present. Commercial rotation age may be 70+ years. Uneven-aged management is possible through selection harvest of groups of trees. On poor oak sites either even-aged management with regeneration harvest through clearcutting or converting to pine is recommended. Pulpwood rotation on poor sites is 40 to 60 years. The usual practice for pine is even-aged management with a regeneration harvest through clearcutting. Then, the site is prepared, pine is planted, and in several years the trees are released from competing vegetation regrowth. Commercial rotation age for pine is 40 to 50 years.

Lowland Hardwoods

The lowland hardwoods (Trimble *et al.* 1974) type is also known as the bottomland hardwoods, flood plain hardwoods, or swamp hardwoods. It occurs throughout both regions and varies mostly with the type of landscape on which it occurs. It can be found in all Ecoregion Sections and in Kuchler's Elm-Ash or Northern Flood Plain Forest type. It includes American elm, black willow, green ash, red maple, silver maple, boxelder, and several oak species.

On good sites sawtimber is the usual timber objective and on poor or wet sites pulpwood is the usual objective.

The preferred silvicultural practice is usually even-aged management with regeneration of the type through clearcutting followed by early precommercial treatment to remove undesirable competing shrubs and trees. If pockets of hemlock are present, they can be maintained by a shelterwood harvest with ground scarification. Poor or wet sites, if not converted to spruce, can be regenerated by using the shelterwood system. On good sites in the northern parts of the Lake States, uneven-aged management is recommended with selection harvest of individual trees to prevent shrubs and grasses from invading the site.

LITERATURE CITED

Bailey, Robert G.
1978. Description of the Ecoregions of the United States. 77 p. U.S. Dep. Agric. For. Serv., Ogden, UT.

Benzie, John W.
1977a. Manager's handbook for jack pine in the north-central States. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NC-32, 18 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.

Benzie, John W.
1977b. Manager's handbook for red pine in the north-central States. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NC-33, 22 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.

Filip, Stanley M., and William B. Leak.
1973. Northeastern northern hardwoods. *In* Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric., Agric. Handb. 445, 114 p.

Gibbs, Carter B.
1973. Northeastern spruce-fir. *In* Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric., Agric. Handb. 445, 114 p.

Johnston, William F.
1977a. Manager's handbook for black spruce in the north-central States. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NC-34, 18 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.

Johnston, William F.
1977b. Manager's handbook for northern white-cedar in the north-central States. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NC-35, 18 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.

Kuchler, A. W.
1964. Potential natural vegetation of the conterminous United States. Am. Geogr. Soc. Special Pub. 36, 156 p. Am. Geogr. Soc., NY.

Little, S., D. E. Beck, and L. Della Bianca.
1973. Eastern white pine. *In* Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric., Agric. Handb. 445, 114 p.

Marquis, David A.
1973. Cherry-maple. *In* Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric., Agric. Handb. 445, 114 p.

Marquis, David A.
1976. Silviculture of eastern hardwoods. *In* The scientific base for silviculture and management decisions in the National Forest System. 58 p. U.S. Dep. Agric. For. Serv., Washington, DC.

Ohmann, Lewis F., and Robert R. Ream.
1971. Wilderness ecology: virgin plant communities of the Boundary Waters Canoe Area. U.S. Dep. Agric. For. Serv., Res. Pap. NC-63, 55 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.

Ohmann, L. F., H. O. Batzer, R. R. Buech, D. C. Lothner, D. A. Perala, A. L. Schipper, Jr., and E. S. Verry.
1978. Some harvest options and their consequences for the aspen, birch, and associated conifer forest types of the Lake States. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NC-48, 34 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.

Perala, Donald A.
1977. Manager's handbook for aspen in the north-central States. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NC-36, 30 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.

Trimble, G. R., Jr.
1973. Appalachian mixed hardwoods. *In* Silvicultural systems for the major forest types of the United States. U.S. Dep. A Agric., Agric. Handb. 445, 114 p.

Trimble, George R., Jr., James H. Patric, John D. Gill, George H. Moeller, and James N. Kochnederfer.
1974. Some options for managing forest land in the central Appalachians. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NE-12, 42 p. U.S. Dep. Agric. For. Serv., Northeast. For. Exp. Stn., Upper Darby, PA.

Tubbs, Carl H.
1977. Manager's handbook for northern hardwoods in the north-central States. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NC-39, 29 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.