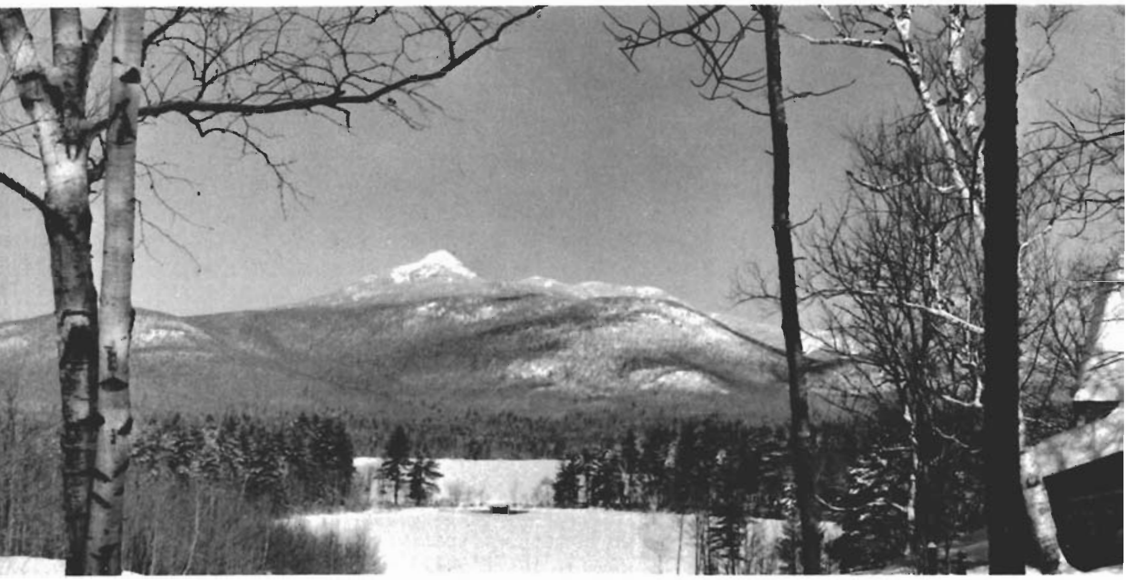
A Silvicultural Guide for PAPER BIRCH in the Northeast



by David A. Marquis
Dale S. Solomon
John C. Bjorkbom

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NORTHEASTERN FOREST EXPERIMENT STATION, UPPER DARBY, PA.
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
RICHARD D. LANE, DIRECTOR

The Authors

DAVID A. MARQUIS received his Bachelor of Science degree in forestry from The Pennsylvania State University in 1955 and his Master's degree from Yale University in 1963. He joined the Northeastern Forest Experiment Station at Laconia, New Hampshire, in 1957, where he studied problems of regeneration and thinning in northern hardwoods. He is now serving on the Timber and Watershed Management Research staff at the Station's headquarters in Upper Darby, Pennsylvania.

DALE S. SOLOMON, associate mensurationist, joined the Northeastern Forest Experiment Station in June 1962 after earning his Master's degree in forestry from Yale University. He had earned a Bachelor's degree in Forestry from The Pennsylvania State University in 1961. Since 1962 he has worked on the Station's beech-birch-maple silviculture project of the research unit located at Durham, New Hampshire.

JOHN C. BJORKBOM received his Bachelor of Science degree in forestry at Pennsylvania State College in 1938, and worked 3 years for the Pennsylvania Department of Forests and Waters (interrupted by military service). He joined the Northeastern Forest Experiment Station in 1948, working in forest survey in the Northeast and doing research with northern hardwoods in New Hampshire. In 1959 he was assigned to the Northeastern Station's unit at Orono, Maine, where he is studying the problems of regeneration and management of paper birch.

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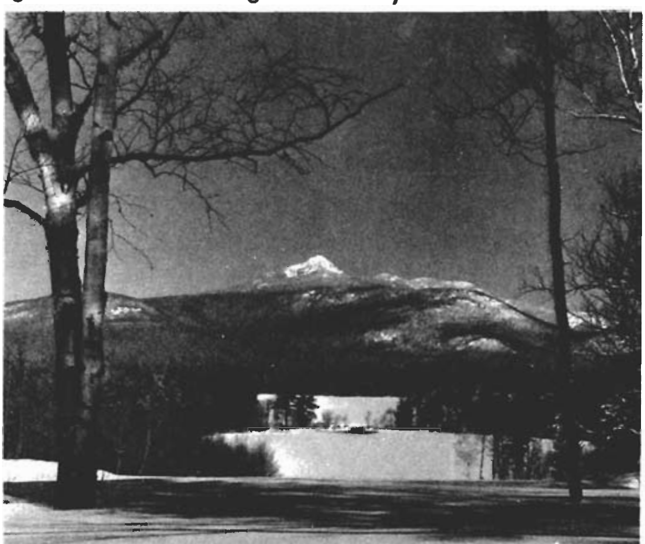
Purpose and Scope

THE PURPOSE of this paper is to provide a practical guide to the management of paper birch stands for timber production. Both the establishment of new stands and the culture of existing stands are covered. Background information on paper birch silvics, silviculture, and management is followed with a set of prescriptions describing specific treatments to be applied for a range of stand conditions and management objectives. A limited amount of information is also provided on the management of paper birch stands for aesthetic and other purposes (fig 1).

This guide is applicable only to pure paper birch stands—those in which at least 50 percent of the basal area is paper birch or those immature stands that can be modified through cleanings and thinnings to produce a stand containing at least 50 percent of the basal area in paper birch at maturity. This guide may also be used in mature stands containing less than 50 percent paper birch where the management objective calls for regeneration to paper birch. Separate guides for management of northern hardwood or spruce-fir stands containing paper birch in lesser proportions are now being prepared.

Recommendations given in this guide may be applied throughout the commercial range of paper birch in Maine, New Hampshire, Vermont, Massachusetts, and New York.

Figure 1.—Paper birch trees are one of the major ingredients of New England scenery.



A Valuable Tree

Paper birch is one of the most valuable timber trees in New England and New York. Its white sapwood, straight grain, smooth texture, and the ease with which it can be machined have made it the long-time favorite of the turning industry. As a result, it is turned, veneered, and stamped into a thousand and one useful products.

Although yellow birch is generally considered the prime timber tree in New England and New York because of the premium prices paid for veneer-quality logs (up to $350 per thousand board feet at the mill in 1968), the larger logs of paper birch also command high prices. Furthermore, woods-run prices are often higher for paper birch than for any other associated species because of the high average quality and the fact that smaller sizes of paper birch are also utilized for high-value products. Paper birch boltwood brings stumpage prices of $15 to $25 per cord (equivalent to $30 to $50 per thousand board feet) in 1968.

Paper birch is also faster growing than its valuable associates, so that it may be possible to produce two crops of paper birch

Figure 2. — Some roadside groves of paper birch, such as this one at Shelburne, New Hampshire, are far more important for their aesthetic value than for the timber they contain. But other roadside stands can contribute to both values simultaneously.

in the time required for a single rotation of yellow birch or sugar maple. The relatively short rotation possible with paper birch makes investments in intensive culture, such as early thinnings, economically feasible. Because of its fast growth and its high value in small sizes, paper birch may actually be cultured more profitably than any other hardwood in the region.

Paper birch is also a valuable tree aesthetically. Its showy bark makes it a distinctive feature of the northern landscape. Roadside groves of paper birch are important tourist attractions in a region where recreation is a major industry (fig 2).

OCCURRENCE IN THE NORTHEAST

Paper birch is one of the principal components of three forest types as recognized by the Society of American Foresters: the paper birch type, the paper birch-red spruce-balsam fir type, and the white spruce-balsam fir-paper birch type. In addition, it is an associate species in 13 softwood types and 4 hardwood types. The area in softwood and hardwood types is about equal. These forest types containing paper birch cover about 81 percent of the commercial forest land in the region. Pure paper birch stands probably cover no more than 2 or 3 percent of this area.

Paper birch is found most often in even-aged stands that have developed after heavy cutting or fire. Paper birch trees are also found in uneven-aged stands as scattered long-lived individuals or occasionally as small groups where cutting or some natural disturbance created a canopy opening.

In New England, paper birch occurs naturally throughout Maine, New Hampshire, Vermont, western Massachusetts, and northwestern Connecticut. In New York, this species is found principally from the Catskill region north to Canada, with a scattering throughout most of the remaining area.

The commercial range includes northern New England, the Berkshire Hills region of Massachusetts, and the Taconic Mountain region of New York.

Paper birch is a cold-climate tree. It occurs in areas where killing frosts can occur in the spring as late as the first week in June, and in the fall as early as the first week in September.

The average annual precipitation within the commercial range varies from 35 to 45 inches, with about one-half occurring as snow.

For the most part, paper birch grows at all elevations and on all aspects and slopes. However, it occurs only at the higher elevations and on the cooler north- and east-facing slopes in the southern portions of its natural range.

In general, paper birch occurs on podzol soils throughout most of its commercial range. However, some paper birch stands also occur on brown and gray-brown podzolic soils. Within these three great soils groups, numerous soil series and soil types are satisfactory for growing paper birch. These soils are mainly glacial tills and outwash derived from granites, schists, gneisses, sandstones, shales, slates, and limestones.

Paper birch occurs over a wide range of soil moisture conditions. It may be somewhat more abundant on drier sites than on wet or poorly drained soils. The best soils are characteristically acidic, relatively deep, moist, and moderately well-drained. Relatively thick organic horizons are also characteristic of the better sites.

The net volume of paper birch growing stock amounts to slightly more than 1.6 billion cubic feet (including 1.8 billion board feet of sawtimber). About 86 percent of this is in northern New England, 10 percent in New York, and the rest in southern New England.

Small diameter trees are the rule. In New Hampshire, 80 percent of the growing-stock volume is in pole-size trees; in Maine, 72 percent is in these small trees.

LIFE HISTORY

Silvics

Paper birch is a monoecious species: both male and female flowers are borne in catkins on the same tree. The male flowers are formed in late autumn or early winter. In the winter months they average about 1 inch long and are clearly visible from the ground. Their relative abundance at this time is a good guide to the size of the seed crop the following fall—barring unforeseen catastrophies to either the male or female catkins. Before opening in the spring, the male catkins elongate to as much as 4 inches. The female catkins appear with the leaves in the spring; and they average 1 to 1¼ inches long. They ripen during the summer; and when fully ripe they are generally 1 to 2 inches long.

Paper birch trees begin bearing seed when about 15 years old, the optimum age extending from 40 to 70 years. Good seed crops occur about every other year. These crops may average about 1 or 2 million seeds per acre. Bumper seed crops are much less common, occurring only about 1 year in 10.

Seed dispersal begins as early as August and continues throughout the winter, but most dispersal occurs before the ground is snow-covered. Seed is dispersed by the wind and, being light in weight, can be carried long distances. However, most seed falls within 1 or 2 hundred feet of the parent tree.

Germination appears to be related to the size of the seed crop; germination is high for large crops and low for small crops. In bumper seed years, germination is uniformly high regardless of time of seed dispersal. In less productive seed years, germination is lowest at the start of seed dispersal and then improves. Paper birch sometimes produces parthenocarpic fruits—empty seeds resulting from pollination failure.

Paper birch seeds are very small (a paper birch seed weighs only about 1/50 as much as a white pine seed, for example) and thus are very sensitive to moisture and temperature conditions at germination. The newly germinated seedling is likewise small and sensitive to environmental conditions for the first few months. Even under favorable conditions, field germination is often less than 10 percent, and under average conditions it is less than 1 percent. Mortality during the first season may average 50 to 75 percent. Thus between 20 and 400 seeds may be needed to produce a single 1-year-old seedling.

Seedbed condition is most important to the regeneration of paper birch. Mineral soil is desirable for germination because of its favorable moisture condition. Mineral soil warms up faster than the loose organic horizons but does not reach the very high temperatures occasionally found on the organic seedbeds. However, soil nutrients are concentrated in the organic layers, so that growth of paper birch is better on organic seedbeds. A mixed organic-mineral soil seedbed provides best conditions. Undisturbed litter or humus seedbeds are not usually satisfactory.

Light is also a critical factor. Regeneration sites fully exposed to sunlight dry out rapidly and often reach excessively high temperatures, leading to seedling damage or mortality. But, as the new seedlings develop, they need overhead light for both survival and growth throughout the rest of their lives.

Paper birch trees are intolerant—their ability to endure shade is relatively low. They are less tolerant than their common forest tree associates—principally sugar maple, beech, yellow birch, red spruce, white spruce, and balsam fir. For this reason paper birch generally disappears from a stand after one generation, leaving only the more tolerant species.

Paper birch is a short-lived, fast-growing tree. Trees of seedling origin reach maturity as early as 60 years of age, with a maximum age of about 140 years. Sprouts are shorter lived and usually mature at 50 to 60 years, with a maximum age of 70 to 90 years.

The most rapid growth in height and diameter occurs in the first 20 to 30 years. After this, the growth rate begins to fall off. Diameter growth rate can be increased by thinning, particularly if the thinnings are begun when the trees are young and their crowns are still expanding rapidly.

In pure stands, paper birch matures and decays earlier than when in mixture with other hardwoods or with conifers. In mature stands, the trees attain an average height of 70 to 80 feet and an average diameter of 10 to 12 inches. On the best sites, an occasional tree in old stands may exceed 30 inches in diameter and 90 feet in height.

In forest types where paper birch occurs in mixture with spruce and fir, it is not unusual to have a two-storied forest with paper birch as the overstory species. To a lesser extent, this situation also occurs when paper birch is mixed with the more tolerant hardwoods.

Principal Enemies

Many agents cause damage to paper birch. Their effects should be minimized through proper management.

Birch dieback reached epidemic proportions in certain parts of the paper birch commercial range in the 1940's and early 1950's. Large proportions of the birch timber were killed or damaged. Symptoms included lowered vigor, reduced growth, and a dying back of twigs and branches. The causes of birch dieback have never been completely identified, although the malady appears to be the result of complex soil and climatic factors, perhaps confounded by the activities of pathogens and insects. The dieback condition has subsided and is not presently considered an important threat to paper birch management. However, one cannot assume that the conditions initiating dieback will not someday recur.

Older residual paper birch trees have sometimes exhibited symptoms similar to dieback after a partial cutting. This post-logging decadence is presumed to be the result of changes in the environment resulting from the cutting operation. However, this decadence has invariably occurred only among trees that were at or near maturity.

There are no proven ways to avoid birch dieback and post-logging decadence. Maintenance of high vigor through periodic thinnings begun at an early age may help to avoid or reduce future damage from dieback. And avoidance of heavy partial cuts in paper birch stands over about 60 years old should reduce the incidence of post-logging decadence.

Other than birch dieback, which has the potential to cause much mortality, the agents most damaging to paper birch appear to be microorganisms that cause discolorations and decays. Branch stubs provide the major avenue of entry for the pathogens, which progressively discolor and then decay the xylem tissue. Discolorations alone sometimes reduce value. Red heart, which is not a natural heartwood formation, is one type of discoloration that is well known; it limits the value of the wood for some uses.

The column of discoloration and decay in the bole is almost always limited to the central core of wood corresponding to the tree size at the time of wounding or branch death. This important fact provides a basis for controlling damage, for if the formation of new branch-stub infection courts can be avoided after the tree has attained a diameter of about 4 inches, the damage can often be avoided entirely, or at least it can be restricted to the central 4-inch knotty core, which is not used for veneer and is of low quality for sawtimber.

To do this, it is necessary to encourage pruning (either natural or artificial) of young trees, and then provide them with ample growing space as they reach pole size to reduce or stop natural pruning and encourage rapid healing of any branch stubs that do occur. It is also important to encourage pruning (either natural or artificial) of branches while they are small. Stubs of large branches or stubs of branches that formed an acute angle with the main stem (such as occur when the leader is lost and a lateral assumes dominance) are particularly serious infection courts for pathogens. In addition to the control measures mentioned above, attempts to grow paper birch should be restricted to appropriate sites. Red heart and other discolorations are thought to be much more serious on poor sites.

The principal fungi causing decays in paper birch include *Poria obliqua, Fomes igniarius,* and *Pholiota* spp.

Root problems are another source of damage to and reduced yield from paper birch. The root rot fungus *Armillaria mellea* (shoestring fungus) is often associated with a condition referred to as collar crack on paper birch. Such trees have reduced growth rate because of the root infection and are more liable to decay and wind breakage. Other fungi infect paper birch roots and cause similar damage. Trees with visible symptoms of root infection should be removed in thinnings. Again, maintenance of vigor, and care in selection of site, will reduce losses from this cause.

Many insects attack paper birch. Prominent among the leaf feeders and defoliators are the forest tent caterpillar, *Malacosoma disstria;* the birch skeletonizer, *Bucculatrix canadensisella;* the birch leaf miner, *Fenusa pusilla;* the birch leaf-mining sawfly, *Phyllotoma nemorata;* and the birch casebearer, *Coleophora salmani.* The bronze birch borer *Agrilus anxius* attacks the boles of paper birch trees. It became well known because it was often associated with birch dieback. However, this borer usually attacks trees that have been weakened by some other agent, and it is not considered a primary damaging agent. Cambium miners such as *Agromyza pruinosa* cause a defect in birch lumber known as pith-ray flecks. This injury sometimes makes wood unsuitable for fine-grade veneers. Ambrosia beetles such as *Trypodendron betulae* are also important because their dark-stained galleries are an important defect in birch lumber. Insects such as *Apion walshii,* and the fungi that are associated with them, also cause considerable damage to paper birch seeds during some years.

Sapsuckers, deer, and other animals cause relatively minor damage to paper birch, although any of these agents may occasionally cause more serious problems in local areas.

The yellow-bellied sapsucker, *Sphyrapicus varius,* damages paper birch trees by pecking holes through the bark to get sap. These holes often result in discoloration and ring shake and severe sapsucker injury may lead to mortality in trees of all sizes.

Browsing by deer can cause considerable damage to paper birch regeneration. Sprouts are subject to severe browsing, and if this is continued, mortality follows. However, lightly browsed paper birch can rapidly grow above the reach of deer. Thus, if birch is to be regenerated, heavy deer browsing must be avoided.

Site Index

Site index curves for paper birch, based on a breast-height age of 50 years, are given in the appendix (fig. 6).

In mixed stands, it may be necessary to use measured site index for one species to predict the site index of another. Figure 7 (appendix) shows the relationship among site indices of paper birch, yellow birch, sugar maple, and white ash. For example, if the measured site index of yellow birch is 70, then the comparable site index for paper birch would be about 76.

Average site index for paper birch is about 60 to 70 feet. The potential production of a paper birch stand with a site index of

75 or better is high, while a site index of 55 represents fairly low potential.

The best sites commonly occur at the lower elevations, on the northeast aspects, on deep and moderately well-drained soils having thick organic horizons. The poorest sites often occur at the higher elevations, on southwest aspects, on shallow soils that are excessively drained and have shallow organic horizons.

Management Objectives

Management objectives will be determined primarily by the species mixture present or desired and by the type of products to be produced.

Most paper birch stands contain a mixture of other species, many smaller than the paper birch, perhaps even occupying intermediate or suppressed crown positions. It is fairly common for them to outnumber the paper birch stems, even in stands where paper birch represents well over half of the basal area. Stands containing 100 percent paper birch are virtually impossible to attain.

Paper birch stands yield a variety of products. Even intensive culture for paper birch veneer logs would normally result in the production of considerable additional volume in lower grade products. The management objective, therefore, will normally be the production of a mixture of products with a maximum dollar return. Usually this means that the mixture of products will have the highest possible proportion of veneer logs, sawlogs, and boltwood, and a minimum proportion of pulpwood. However, some owners on some lands may have quite different objectives. For example, a bolt mill may prefer to maximize boltwood production, or a campground owner may prefer to maximize the number of paper birch stems with little regard to their value as timber.

Since we must deal with a mixture of species and products, there will be a choice of management objectives. Five choices are provided in this guide.

FOR PAPER BIRCH TIMBER

For this, paper birch would be favored over all other species. Although the other species would not be removed unless they interfered with paper birch development, all treatments would be aimed at maximizing the proportion of paper birch, and its growth and yield. Rotations would be based on paper birch alone; when the final paper birch harvest cutting is made, a new stand of birch would be regenerated. Stands managed in this way should contain at least enough paper birch to meet the specifications in table 1 (appendix).

Objective 1

Maximum production of paper birch veneer logs and sawlogs. Some boltwood will also be produced. Site index should be 60 or above for this objective.

Objective 2

Maximum production of paper birch boltwood. This objective might apply in areas where short rotations are desired, where veneer and sawlog markets are absent, or on sites where paper birch will not grow to sawlog size (site index of less than 60).

FOR TIMBER OF MIXED SPECIES

For this choice, all valuable species might be treated equally. In thinnings, for example, some paper birch might be removed to favor higher quality stems of other species or to obtain a better balance of species. Rotation would be based on all species present rather than on paper birch alone. Where the associated species are primarily other valuable and long-lived species such as yellow birch, sugar maple, white ash, red spruce, and white spruce, the paper birch would be harvested about half-way through the rotation and a second harvest would later be obtained from the longer-lived species. Stands managed for mixed (long-lived) species should also have at least enough paper birch to meet the specifications in table 1.

Objective 3

Maximum production of high value products of all species. This objective is similar to objective 1 except that paper birch would be considered to be on the same level of desirability as the associated species. The other species included here are those long-lived hardwood and softwood associates that mature considerably later than paper birch.

Objective 4

Maximum production of high-value products of all species on areas where other forest uses are incompatible with large clearcuttings or large-area strip cuttings. It is assumed that very carefully regulated cuttings that do not create large openings will be permissible. This objective might be used on commercial forest lands readily visible from tourist routes and scenic highways, in areas adjacent to recreation areas, and in roadside zones where cutting is permitted. It may also apply on small ownerships where clearcuttings of 1 acre or larger are undesirable for one reason or another.

FOR AESTHETICS AND OTHER PURPOSES

Objective 5

Maximum production and perpetuation of paper birch stems in paper birch groves and roadside scenic areas, paper birch seed-production areas, and other locations where the paper birch is desired for its appearance or other values and where timber production is secondary or is even prohibited.

A Management Program for Timber

Pure stands of paper birch can be established and maintained only under some form of even-aged management. Small proportions of paper birch can be maintained under uneven-aged management if group selection or heavy individual tree selection cuttings are employed, but stands containing 50 percent or more of paper birch cannot be achieved in this way. Therefore this guide contains no recommendations for uneven-aged management.

Even-aged management may be begun in stands of any age.

More often than not, stands being placed under even-aged management for the first time need a period of thinning, stand improvement, and conditioning before harvest cutting to reduce the number of age or size classes, to stimulate seed production, and to allow a majority of the trees in the stand to reach economic maturity. Too often immature stands are harvested in a rush to initiate even-aged management, and many pole timber and small saw-timber trees are cut at a time when they are making their greatest growth in value. The prescriptions presented later provide guides on when to harvest the existing stand and regenerate a new one.

REGENERATION

Many factors affect the establishment and early development of paper birch regeneration. Soil, aspect, slope, elevation, quantity and proximity of the seed supply, rainfall, amount of shade, seedbed conditions, amount of competition from other species, and deer browsing are all important. During the first year, when seeds are germinating and seedlings becoming established, abundant moisture and avoidance of excessively high soil temperature are critical requirements. Droughty soils and steep south-facing slopes are often adverse sites for these reasons. A limited supply of seed or an unusually dry year also create adverse conditions on otherwise satisfactory sites.

Sprouts are not affected nearly as much as seedlings by droughty conditions, so that sprout reproduction may supplement seedling regeneration on some areas. Sprouts are seldom abundant enough to be the major source of reproduction, nor are sprouts as desirable as seedlings in final quality. Nevertheless, trees that develop from paper birch stump sprouts can often be used for high-value products. Although the recommendations and prescriptions presented in this guide are based on seedling reproduction, it should be remembered that some stump sprout reproduction may be available to supplement the seedlings if needed.

In many situations, clearcutting or seed-tree cutting of the mature stand will be enough to obtain satisfactory seedling paper birch regeneration. In other cases, special measures will be required: cutting methods that provide shade, seedbed preparation, and direct seeding or planting.

Clearcutting and Seed-Tree Cutting

Clearcuttings up to 100 acres in size, either with or without seed trees, will be used most frequently for harvesting the mature stand and regenerating a new one. Except for areas where environmental conditions are expected to be adverse (as discussed in the following section), or for years when seed crops are expected to be poor, or for stands that do not contain paper birch seed-producing trees, clearcutting or seed-tree cutting alone should provide adequate regeneration.

Whether or not seed trees need to be retained will depend on the size of the opening and the season of the year in which cutting is done. If the opening is relatively small—a maximum width of about 300 feet—enough seed will usually be dispersed from bordering trees so that seed trees are not needed in the clearcut area. Where the clearcutting is wider than 300 feet, seed trees may still not be needed in the clearcut area if cutting is done between late fall and early spring. Seed dispersed in the fall from trees on the area to be cut will provide for regeneration the next spring. However, if cutting is done during the summer months—after the seed from the previous fall has lost viability and before the new crop is ripened—there will be little seed in the humus to establish a new stand. (Paper birch seeds do not usually remain dormant and viable in the humus more than 1 year).

Therefore seed trees should be retained in any large clearcuttings made in June, July, August, or September. About four well-distributed paper birch seed trees should be retained on each acre to insure an adequate seed supply during normal seed years. As few as two seed trees per acre may suffice during a bumper year, but such seed crops occur infrequently.

Summer clearcutting with seed trees is recommended for most situations, because summer cuttings are desirable for reasons other than seed supply (seedbed scarification is slightly more widespread after summer logging and additional scarification is more easily obtained). This recommendation is based on the requirement that enough paper birch seedlings be established to develop a stand of at least 50 percent paper birch. Large summer clearcuttings without seed trees would provide some paper birch regeneration, but usually not enough to permit management as a paper birch stand.

The above recommendation for summer clearcutting with seed trees is based on the assumption of an average seed crop. If the seed crop is expected to be below average (based on counts of male catkins), the cutting should either be postponed a year or special regeneration methods such as strip cutting and direct seeding should be considered.

After clearcutting of the merchantable trees, all remaining stems over 1.5 inches d.b.h. (except seed trees) should be cut or killed by girdling or with an herbicide. Stumps of vigorously sprouting species such as red maple should be drenched with a basal spray of 2, 4, 5-T ester in oil (or other effective herbicides). Basal spraying of stumps and removal of unmerchantable stems is often done at the same time, the year after cutting. The seed trees may be removed about 2 years after the cutting.

Loggers should be encouraged to scarify as much of the soil surface as possible during the felling and skidding operations. The use of heavy tractor skidders usually provides more scarified area than horses or lighter equipment. Exposure of mineral soil in this way will increase the proportion of birch in the new stand. However, removal of the humus layer should be avoided because this layer provides most of the nutrients required for adequate growth and development. A mixing of humus and mineral soil is most desirable. Logging during the winter when the ground is frozen or snow-covered will result in very little scarification.

Care must be taken in any cutting to avoid soil erosion. Logging roads and scarified areas especially need care. Waterbars and seeding of skidroads should be employed where the slope is 10 percent or more. Logging roads and skid trails should be kept as nearly on the contour as possible and should be kept away from streams and other watercourses. Necessary stream crossings should be at right angles to the stream and should be protected by culverts where possible.

Special Methods for Difficult Areas

Clearcutting or seed-tree cutting alone will not always result in enough birch regeneration to develop paper birch stands. Special measures may be needed if the stand to be harvested is located on a south-, southwest-, or west-facing slope in excess of 10 percent, or if it is on a somewhat excessively drained soil, or if a poor seed crop is expected, or if there are fewer than four well-distributed paper birch seed-bearing trees per acre. If site index is less than 55, or if the soil is excessively drained, paper birch will probably not grow well on the site even if established there; other species should be considered for these areas.

There are three measures that can be taken to increase birch regeneration on areas with the above characteristics: the use of harvest cuttings that provide shade, the scarification of seedbeds, and the use of direct seeding or planting. These three measures may be used singly or in combination, depending upon the severity of the conditions.

Cutting methods that provide shade.—The use of cuttings that provide at least partial shade will provide higher surface soil-moisture conditions and lower surface soil temperatures and thus will increase birch seed germination and seedling survival. Where there are only moderately adverse conditions, or where investments in scarification or seeding do not seem desirable, the use of shade-type cuttings are recommended. Shade-type cuttings should be used rather than clearcutting or seed-tree cutting if a poor seed crop is expected.

The best shade cuttings are narrow strips (50 feet wide) oriented in an east-west direction, with 100-foot-wide uncut strips between them (fig. 3). After an establishment period of 2 years, a second series of 50-foot strips are cut on the south side of the original ones. The remaining strips are then cut after a second establishment period of 2 years. As in large clearcuttings, all unmerchantable stems are removed, vigorous sprouting is

Figure 3.—Clearcutting in narrow strips. The open shade cast by trees bordering these strips provides excellent conditions for paper birch regeneration.

controlled, and scarification is encouraged during logging, with appropriate measures to avoid erosion.

Small patches (less than 1 acre) may also be used like strips (fig. 4). They provide essentially the same conditions, except that new patches are much more difficult to fit in among older ones and to systematically cover the entire area in a particular stand. Such cuttings are most useful when used in combination with selection cutting under uneven-aged management and when no attempt is made to systematically cover the entire area with patches. Although their use is limited in even-aged management, patches may be employed in special circumstances on very small tracts, roadside areas, parks, or other areas where there is insufficient space for strips or where the geometric appearance of clear-cut strips would be undesirable.

Shelterwood cuttings might also be used where strips are undesirable or impractical, although little research data are avail-

Figure 4.—A small patch cutting for paper birch regeneration immediately after cutting. Relatively little seedbed scarification is obtained from logging in this type of opening.

able about such cuttings and they are generally less satisfactory than strips or patches. The first cut should remove 60 percent of the total stand basal area. The residual stand should include four to five paper birch seed trees per acre. All unmerchantable trees down to 1.5 inches d.b.h. should be eliminated at this time. The second cut, after an establishment period of 2 years, should remove the remaining overstory. Heavy cuts (such as the first shelterwood cut) in older stands sometimes result in decadence among residual birch trees, but damage or loss in value is avoided if the second cut is made as soon as the new reproduction is established.

Seedbed preparation.—Seedbed scarification which exposes some mineral soil and mixes it with the humus layers will materially increase the amount of birch regeneration. A scarified seedbed is probably more important than any other factor. Unfortunately, even summer logging normally provides suitable scarification on less than 10 percent of a clearcut area. Scarification from logging in narrow strips often covers a greater proportion of the area if truck roads are laid out to encourage skidding within the strip.

Additional scarification is best achieved through use of a large tractor with dozer blade or rock rake. Great care must be used to avoid removing the humus layer. Alternate raising and lowering of the blade, and backfilling of scraped material with the blade, will usually accomplish the desired result. The goal of scarification should be to expose mineral soil on about 50 percent of the cut area.

The cost of scarification ($15 to $30 per acre) precludes its use on any but the best sites. Scarification should probably be limited to areas with site index of 70 or above. However, the tractor can uproot many of the small unmerchantable trees, thus avoiding the need to remove them with herbicide. As techniques and machinery for scarification improve and costs are reduced, scarification will be justified on many of the better areas. Scarification may be used either in large clearcut areas or in shade-type cuttings.

Direct seeding and planting.—If paper birch seed-producing trees are completely lacking or extremely scarce in the area to be cut and surrounding stands, or if cutting must be done during a poor seed year, it may be necessary to employ direct seeding or planting to obtain paper birch regeneration. As a rule of thumb, four well-distributed paper birch seed-bearing trees per acre should be present to provide adequate natural seedfall during normal seed years.

Because only a small amount of seed can be applied economically in a direct-seeding operation, it is imperative that the seed be sown on a suitable seedbed. Thus scarification should normally be considered along with seeding. If the high cost of scarification is prohibitive, direct seeding may still be appropriate where the harvest cutting is made in narrow strips to provide a favorable microenvironment and to maximize scarification from the logging. In such cases, seed should be sown only on the areas actually scarified. Scarification may be done any time up to 1 year before seeding.

If paper birch seed is to be stored for more than a few weeks before sowing, it should be stored carefully to avoid loss in viability. After collection, the seed should be spread out in shallow trays to dry at room temperature for about 2 weeks before storage. After drying, the seed should be stored in polyethylene bags or glass jars, tightly sealed, at low temperature. A refrigerator or some other cold-storage facility is ideal and will keep paper birch seed viable for 2 or more years, if necessary.

Paper birch seed should be sown at the rate of at least ½ lb. per acre. It may be sown with a cyclone seeder if mixed with sawdust filler in the ratio of 2 parts sawdust to 1 part seed by volume. Seeding may be done either in the spring (as soon after snowmelt as possible) or in the fall (after leaf fall and before snowfall).

Planting of birch may be considered as an alternative to direct seeding. Although the planted seedlings are sometimes heavily browsed by deer, planting may be more satisfactory than seeding in difficult areas.

INTERMEDIATE STAND CULTURE

Minimum Stocking Requirements

One of the first considerations in placing an existing stand under management is whether or not it contains enough paper birch and other crop-tree species to justify management. Table 1 (appendix) provides some guides to the minimum stocking required for the various management objectives. Those stands that do not meet the minimum stocking requirements should be handled with the northern hardwood or spruce-fir guide, as appropriate.

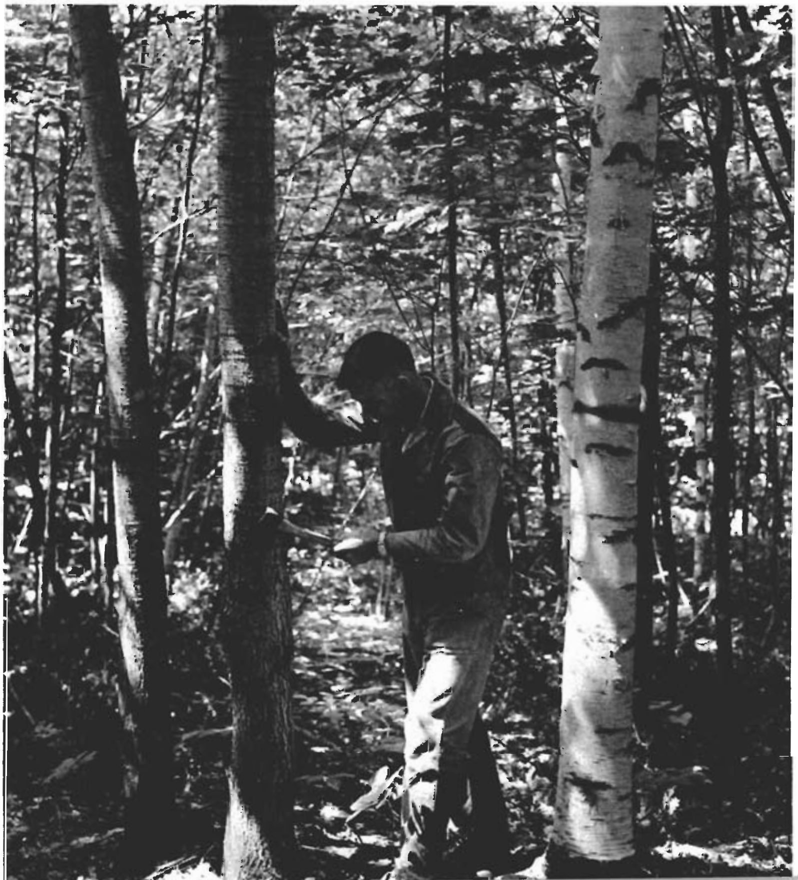
Cleaning

Cleaning involves the removal of weed species such as pin-cherry, red maple sprouts, aspen,[1] and striped maple in seedling-or-sapling stands (fig. 5). Individuals of less desirable form may also be removed at this time, regardless of species. This treatment is justified economically only on the best sites where competition

[1]The aspens are considered weed species in many paper birch areas because aspen markets are usually absent or, where present, prices are so low that they preclude effective management for these species. Where they occur in large numbers, aspens are the most serious competitors of paper birch so they should be removed as early in the life of the stand as possible.

Where aspen is to be retained as a crop tree along with paper birch, no attempt should be made to retain longer-lived species, and the aspen and birch should be cleaned or thinned as early as possible to insure survival of the desired stems.

Figure 5.—An aspen is being killed to release the adjacent paper birch crop tree. Thinning in young stands of birch maintains rapid growth and reduces the time required to grow crop trees to desired size.



is expected to reduce the proportion of crop trees below the minimum stocking levels. Cleaning may also be justified in certain scenic or recreation areas where a large proportion of paper birch is desired for its appearance.

Cleaning may be done by cutting or basal spraying the most serious competitors around selected crop trees when the stand is 5 to 10 years old. If sprays are used, care must be taken to avoid herbicide drift and resulting damage to the crop trees. Approximately 150 crop trees should be released per acre. Release of only 150 crop trees is recommended to keep costs to a minimum; this is the minimum number that will be needed when the stand reaches maturity. The purpose of the cleaning is to insure the survival of this minimum number of crop trees when competition is severe. Crop tree specifications are shown in table 2(appendix).

Pruning

Pruning is economically justified only on the best sites and only on yellow birch and sugar maple crop trees. Paper birch and white ash prune naturally at a fast rate and do not need to be pruned if grown in stands of normal density. The value of the other species does not justify pruning. Pruning of sugar maple and yellow birch crop trees should be considered only on the best sites, at the age of 15 to 20 years (before diameter reaches 4 inches). Only the first 17 feet should be pruned. Pruning of paper birch in scenic areas should be limited to removal of dead, broken, or damaged limbs.

Precommercial Thinning

One or two precommercial thinnings between the ages of 25 and 35 years will be required under most circumstances. Such thinnings are needed to mold species composition as desired, to encourage the crown expansion needed to sustain rapid growth during the latter part of the rotation, and to favor trees of highest quality. Although an investment is required, precommercial thinnings provide a higher rate of return than any other silvicultural treatment. They permit significant shortening of the rotation and attainment of maximum yield.

Approximately 250 to 300 paper birch crop trees should be released per acre. This will provide enough crop trees to form a fully stocked paper birch stand when these trees reach a merchantable size. Where the objective is mixed species, there should be approximately 200 paper birch crop trees and 200 crop trees of longer-lived species. Crop-tree specifications are given in table 2 (appendix).

In some stands, it may not be possible to obtain 250 to 300 paper birch crop trees per acre. In such cases, 150 paper birch crop trees per acre represents about the absolute minimum number required. Stands with fewer paper birch crop trees probably do not warrant precommercial thinnings because there would not be enough paper birch trees to form a fully stocked paper birch stand at maturity.

Trees competing with the crop trees should be removed to give the crop trees ample growing space. However, stocking should not be reduced below the point where the site is fully occupied. (Specific stocking guides are described in the following section). Unwanted trees may be treated with an herbicide, either in frills or with a tree injector.

Commercial Thinnings

Commercial thinnings may begin as soon as the stand attains merchantable size. Initial products will generally be paper birch boltwood and pulpwood of all species. Later thinnings may include some small sawtimber. Thinnings should be planned so as to reduce stand stocking to the level shown in the stocking guide that follows, removing first the non-crop trees, second the trees of lower quality, and third any stems required to improve spatial distribution of the residual trees. Trees with veneer or sawlog grade 1 or 2 potential in the butt log should be retained for the final harvest.

Trees removed in all thinnings will be distributed throughout all crown classes. However, the cut in early thinnings and precommercial thinnings will tend to be concentrated in the upper classes, whereas later thinnings will remove more trees in the lower classes.

Thinning should be timed so that the growth between thinnings provides enough merchantable volume to support profitable logging. Normally a volume equivalent to about 5 cords is required, depending upon the size and quality of trees removed and the products into which they can be cut.

All thinnings should include the removal of cull trees. Normally there will be very few such trees after the first or second thinning.

Stocking Guides for Thinnings

Although total growth per acre is about equal over a wide range of densities for stands of similar site and species composition, diameter growth of individual trees varies greatly within this density range. Best diameter growth occurs at the lower densities, and maximum stand value is achieved by maintaining the stand at the minimum density required for full site utilization. A stocking guide has been developed, specifying desirable stand densities (in basal area) for stands of various mean diameters and numbers of trees per acre (fig. 8, appendix).

Most unmanaged paper birch stands will be within the vicinity of the A line or above in figure 8. Stands that fall in the area above the A line for a given mean diameter, basal area, and number of trees per acre should be considered overstocked. The B line represents minimum stocking for full occupancy. In thinnings, stands should be cut back to not less than the B line to produce good diameter growth and low mortality. Reducing stocking below the B line provides more growing space than can be utilized, and overall stand growth will be reduced. Stands between the A and B lines usually are adequately stocked. The C line represents the point where 10 years of growth will bring the stand up to the B line. Stands between the B and C lines would therefore be considered slightly understocked; stands below the C line would be definitely understocked.

For example: A stand with a mean diameter of 6 inches, 95 square feet of basal area, and 490 trees per acre is overstocked. By thinning this stand back to the B line (the mean diameter usually remains about the same, although this could be altered), the stand would then have 61 square feet of basal area and 313 trees per acre. Assuming negligible mortality (number of trees per acre remains the same), the stand would grow and not need to be rethinned until it has reached approximately 104 square feet of basal area and 7.9 inches mean diameter. Growth, of course, slows down as the stand approaches the A line, and the stand may be thinned before it reaches this density.

Some of the stocking concepts used in figure 8 may also be applied to sapling stands. In figure 9, the area above the A line represents overstocked conditions; the area between the A and B lines represents adequate stocking; and the B line itself represents minimum stocking for full size occupancy. Trees at the B line have ample growing space without competition. Thinnings should reduce stocking to this level to produce good diameter growth of the best trees.

Other concepts used in figure 8 are not applicable in sapling stands. The occurrence of stocking levels below the B line does not necessarily result in reduced yield. These small trees are not merchantable, and the loss of a portion of total stand growth is unimportant because this loss would be on trees that would die before they reached merchantable size. As long as the stand contains enough potential crop trees to attain B level stocking when these trees reach merchantable size, the stand may be considered adequately stocked. If a mean stand diameter of 7 inches is about the lower limit of merchantability, approximately 250 to 260 trees would be required. In stands that receive cleanings and/or precommercial thinnings, mortality among the released crop trees is very low, so that the release of 250 to 300 paper birch crop trees will normally be adequate to provide full stocking when these trees reach a merchantable size.

In unmanaged stands (that will not be cleaned or thinned) mortality is often high, and a larger number of acceptable stems are required to insure that there will be enough to make B level stocking when the stand reaches a merchantable size. Stands that are not at least 80 percent stocked (as determined from a stand diagnosis, using procedures shown on page 30) generally need a cleaning or thinning to insure survival of an adequate number of crop-tree stems.

Schedule of Intermediate Treatments

An idealized schedule of treatments for stands under management from the regeneration phase to maturity is presented in table 4 (appendix). Treatment of stands being placed under management at a later point in the rotation may require a revised schedule to at least partially correct deficiencies resulting from missed treatments. And the entire rotation of such stands may be lengthened. Table 4 represents a general guide for long-term planning. Exact timing of thinnings and other treatments for a particular stand should be determined from the stocking guides and prescriptions rather than from table 4.

HARVEST CUTTINGS

Final harvest cuttings are also regeneration cuttings, and the appropriate type to use depends upon the management objectives and regeneration considerations previously discussed.

Expected rotation ages and sizes are shown for the various species in table 5 (appendix).

Approximate merchantable volume yields in cubic feet per acre from well-stocked stands of various mean diameters are given in table 6 (appendix); the number of years required to reach these volumes are also shown, by site-index classes. Yields for both managed and unmanaged stands are given. Where paper birch is mixed with other species, or where stocking is less than full, the yields for paper birch should be reduced proportionally.

The merchantable volume shown in table 6 is the total volume expected from the final cut. Although specific information is lacking, we estimate that yields from an intensive thinning schedule will produce intermediate yields at least equal to the volumes shown in table 6. For example, under intensive thinning on a site of 70, it would take 56 years to produce a stand of 10 inches average diameter with a volume of roughly 3,830 cubic feet per acre. With thinnings, another 3,830 cubic feet could have been previously removed, for a total yield of approximately 7,660 cubic feet.

A Management Program for Aesthetics and Other Purposes

Management of paper birch stands for aesthetic purposes, where timber production is secondary or even prohibited, requires cultural measures and schedules quite different from those employed for timber production. Larger expenditures for scarification, weeding, noncommercial thinning, and other measures are justified on these scenic areas to obtain the desired results. And the stocking guides for timber production do not necessarily apply to scenic areas where stocking is determined more by appearance than by maximum growth. Some general guides for stocking and scheduling of treatments are given in tables 1, 4, and 5. Some more specific prescriptions follow. These prescriptions may also have application for paper birch seed-production areas.

In scenic areas, regeneration will normally be obtained in rather small irregularly shaped clearcut patches laid out to fit into the landscape with a pleasing effect. All small trees should be cut and all slash should be removed, burned, or lopped so as to create an acceptable appearance. Seedbed scarification and direct seeding should be used as a means of obtaining large numbers of paper birch from which to develop the desired stand. Stump sprouts are especially important sources of reproduction in scenic areas because of the attractive appearance of birch clumps. Planting of paper birch in such areas may also be considered. Seed-production areas may be started in similar fashion, using larger clearcuttings and seed or seedlings of known origin. Fertilization of seedlings during the first few years may aid in establishment. And it may be desirable to provide protection against deer browsing in certain areas.

At about 5 years of age, the stand should be examined for possible cleaning to remove other species where competition is severe. An early thinning should be possible at about 10 years of age to select and favor those individual paper birch that will make up the scenic stand. A minimum of 200 trees should be favored at this stage. As many as 400 to 600 should be favored if possible. The bark of the young trees should turn white by 10 years of age to aid this selection of scenic trees. Early thinnings should be light to encourage height growth and good form.

At 15 to 20 years of age, or when the favored trees reach 4 or 5 inches in diameter, a heavy thinning may be made to establish the desired conditions. Additional thinnings may be made to create orchard conditions if desired. Fertilization may be used at age 15 to 20 years or later to stimulate diameter growth or seed production.

On good sites (70 and above), paper birch can be safely grown to about 100 years of age. On poorer sites, a maximum rotation of about 80 years should be the goal.

Management Prescriptions

STAND DIAGNOSIS

Before a prescription can be written for a given stand, a stand diagnosis must be made. The first task is to determine what area will be considered and treated as a separate stand. The area should be small enough so that it will have reasonably similar stand conditions throughout. Site conditions should also be reasonably uniform (a range no greater than one 10-foot site-index class). However, the area should be large enough to efficiently conduct such operations as thinning, cull removal, and harvesting. There is no optimum size: areas may be as small as 1 or 2 acres or as large as can be conveniently laid out and treated.

Once the limits of the stand area have been determined, basal area and number of trees per acre must be determined. In poletimber and larger stands, basal area may be estimated with variable plot-cruising techniques, using a 10-factor prism. To estimate basal area within 10 square feet of the true value, using the 10-factor prism, 1 randomly located sample point is required per acre, up to a maximum of 50 points.

At each sample point, trees counted to determine basal area should be tallied by 2-inch diameter classes. Only trees in the main crown canopy (dominants, codominants, and intermediates) should be included in these stand measurements. Number of trees per acre may be determined from this tally by multiplying the number of trees in each diameter class by the appropriate conversion value shown on the tally sheet (fig. 10, appendix), and dividing by the number of plots. And basal area per acre is determined by multiplying the average number of trees counted per plot by the prism factor (10).

In addition to basal area and number of trees per acre, it will be necessary to determine paper birch site index. Measurements should be taken on dominant and codominant trees only. Age is determined by increment cores at breast height; total height is obtained by using a Haga altimeter, Abney level, or similar instrument. To estimate total height of the measured trees with acceptable accuracy, at least 10 trees should be measured in stands 50 acres or smaller, or about 1 tree per 5 acres in larger stands; these should be distributed evenly throughout the stand. Site index is then determined from figure 6.

The sample field tally form (fig. 10, appendix) is convenient for recording and summarizing the information needed. Mean diameter and required basal area for stands of that diameter may be read from figure 8. If the stand contains several distinct size classes, decide which one will represent the main stand for future management. Generally this will be the size class with the largest basal area, or the one with the maximum potential. Stand maturity is determined by mean stand diameter, as shown in table 5.

Once completed, the stand-diagnosis tally sheet provides all the information necessary to write a stand prescription.

In young stands (less than 5.0 inches mean diameter), prism cruising cannot be used effectively. The stand measurements required for complete seedling-or-sapling stand diagnosis can be obtained through ordinary plot-cruising techinques. However, a complete diagnosis is not always required in these young stands. It is best to determine site index first; if site is less than 70 in seedling stands or less than 60 in sapling stands, no further stand diagnosis is required because no treatment would be prescribed in these situations. If site index is higher than that indicated above, a complete stand diagnosis should be made.

To make a complete diagnosis in seedling-and-sapling stands, one randomly located plot is required per acre up to a maximum of 50 plots. The appropriate plot size is one that contains 113 square feet (a circular plot with a radius of 6 feet or a square plot 10.6 feet on each side). Circular plots are easiest to use if a stick cut to the length of the plot radius is used to determine the plot limits.

Field measurements on these plots require a count of the number of potential paper birch crop trees, the number of potential crop trees of other species, and the number of non-crop trees on each plot, recorded by 2-inch diameter classes. From these measurements, number of trees per acre, basal area, and mean stand diameter may be calculated. Stocking is then determined by comparing the observed number of crop trees on each plot with the number required for satisfactory stocking for stands of that diameter, as shown in table 3 (appendix). The proportion of plots that contain the required numbers of crop trees represents the percent stocking of the stand.

A sample field tally form (fig. 11, appendix) is convenient for recording and summarizing the information needed. Site index is measured and the other data are summarized in the same manner as for older stands.

PRESCRIPTIONS

The prescriptions that follow are arranged in the form of a key. Using information obtained from the stand diagnosis, begin at item 1 below and follow the subsequent directions. This will lead you to a prescription describing a specific treatment for the stand.

Item 1. If timber production is one of the primary objectives, see item 2. If production of paper birch for aesthetic purposes is the primary objective, see the recommended silvicultural practices on pages 27 and 28.

Item 2. If the mean stand diameter is—
—less than 1.0 inch, see item 3.

—between 1.0 and 5.0 inches, see item 5.
—between 5.0 and 11.0 inches, see item 8.
—over 11.0 inches, see item 12.

Seedling Stands

Item 3. If the stand is 50 percent or more stocked with paper birch stems, it can be managed appropriately as a paper birch stand under this guide. See item 4. If the stand is less than 50 percent stocked with paper birch stems, use the northern hardwood or spruce-fir guide as appropriate.

Item 4. If the stand is 80 percent or more stocked with paper birch stems, or if total stand stocking is below the A-level in figure 9, see prescription A. If the stand is less than 80 percent stocked with paper birch stems, *and* total stand stocking is above the A-level, see prescription B.

Sapling Stands

Item 5. If the stand is 50 percent or more stocked with paper birch crop trees, it can be managed appropriately as a paper birch stand under this guide. See item 6. If the stand is not 50 percent or more stocked with paper birch crop trees, use the northern hardwood or spruce-fir guide as appropriate.

Item 6. If site index is less than 60, see prescription C. If site index is 60 or more but less than 70, see prescription D. If site index is 70 or more, see item 7.

Item 7. If the management objective is for paper birch boltwood, see prescription E. If the management objective is for saw and veneer logs, see prescription F.

Pole Stands

Item 8. If pole-size and larger paper birch crop trees represent at least 50 percent of B-level stocking (fig. 8), the stand can be managed appropriately as a paper birch stand under this guide. See item 9. If paper birch crop trees do not represent at least 50 percent of B-level stocking, use the northern hardwood or spruce-fir guide as appropriate.

Item 9. If the paper birch component of the stand is mature for the site and objective (if the average paper birch diameter equals or exceeds the diameters shown in table 5), see item 13. If the paper birch component is not mature, see item 10.

Item 10. If the amount of merchantable basal area above the B level (fig. 8) is sufficient for a commercial cut,[2] the stand should be thinned. See prescription G. If the amount of basal area above the B level is insufficient for a commercial cut, see item 11.

Item 11. If the stand is located on site of index of 60 or more and total stand stocking is above the A level, see prescription H. If the stand is located on site of less than index 60 or if stand stocking is below the A level, see prescription I.

Sawtimber

Item 12. If paper birch represents at least 50 percent of the total basal area, the stand can appropriately be managed under this guide. See item 13. If paper birch represents less than 50 percent of the basal area, use the northern hardwood or spruce-fir guide as appropriate.

Item 13. If the longer-lived crop-tree component of the stand represents at least half of B-level stocking and if these trees are of adequate quality to produce veneer or sawlogs, the paper birch may be harvested and management of the longer-lived species can be continued. See prescription J. If the high-quality longer-lived crop tree component represents less than half of B-level stocking, stocking will not be adequate after the paper birch is

[2]A commercial cut usually requires about 5 cords per acre, which equals 35 square feet of basal area in 6-inch trees, or 20 square feet of basal area in 8-inch trees, or 15 square feet of basal area in 10-inch trees.

harvested. In this case, or in any case where the management objective is for paper birch alone, the entire stand should be harvested and a new one regenerated. See item 14.

Item 14. If there are fewer than four well-distributed paper birch seed trees per acre in the stand to be cut, or if a poor seed crop is expected (based on counts of male catkins), seed supply may be limiting. See prescription K. If the stand to be harvested is located on a south-, southwest-, or west-facing slope in excess of 10 percent, or if it is on a somewhat excessively drained soil, special regeneration measures may be needed to obtain adequate birch regeneration. See prescription L. If site index is less than 55, or if the soil is excessively drained, paper birch will probably not grow well on the site even if established there; other species should be considered for these areas. If none of the above apply, see prescription M.

PRESCRIPTION A. Do nothing now; the stand should develop to the sapling stage satisfactorily without treatment.

PRESCRIPTION B. Paper birch in these stands are under severe competition. On sites of index 70 or above, cleaning is warranted at this time to reduce the competition and insure survival of the favored species. On sites of index less than 70, cleaning is not warranted. Re-examine these stands in 10 years to consider the possibility of an early precommercial thinning.

PRESCRIPTION C. Do nothing now; re-examine the stand at about age 45 to 50, or in 10 years if the stand is already 40 or more years old.

PRESCRIPTION D. A single precommercial thinning is warranted at about age 30 if total stand stocking exceeds the A level. Attempt to release 250 to 300 paper birch crop trees per acre if the management objective is for paper birch alone, or 200 paper birch and 200 other crop trees per acre if the management objective is for mixed timber. Remove all trees competing with the crop trees but do not reduce stocking below the B level.

PRESCRIPTION E. Apply a single precommercial thinning at about 25 years of age. Attempt to release 300 to 400 paper birch trees per acre but do not reduce stocking below B level. A commercial thinning should then be possible in about 15 years. If stocking is below the A level at 25 years of age, the precommercial thinning should be omitted.

PRESCRIPTION F. If stocking is below the A level, postpone the thinning and re-examine the stand in 10 years. Otherwise, apply two precommercial thinnings at about 25 and 35 years of age. Release 250 to 300 paper birch crop trees per acre (minimum 150) if the management objective is paper birch alone or up to 200 paper birch and 200 longer-lived crop trees per acre (minimum of 100 each) if the management objective is mixed timber. Do not reduce stocking below the B level. Sugar maple and yellow birch crop trees in these stands should be considered for pruning.

PRESCRIPTION G. Thin to B level and release enough crop trees to provide B-level stocking of these crop trees alone 10 years hence. The number to release may be determined from figure 8 by assuming that the present crop trees will increase 2 inches in diameter in 10 years. If the management objective is paper birch alone, these crop trees should be all paper birch; if the management objective is mixed timber, these crop trees should be about half paper birch and half long-lived species.

PRESCRIPTION H. Apply a precommercial thinning to reduce stocking to B level. Release enough crop trees to provide B-level stocking of these crop trees alone 10 years hence. The number to release may be determined from figure 8 by assuming that the present crop trees will increase 2 inches in diameter in 10 years. If the management objective is paper birch alone, these crop trees should be all paper birch; if the management objective is mixed timber, these crop trees should be half paper birch and half long-lived species.

PRESCRIPTION I. Do nothing now and re-examine the stand in 10 years. (No thinning is required if stocking is below the A level; and precommercial thinning is not warranted on sites with an index of less than 60.)

PRESCRIPTION J. Paper birch and other merchantable products should be harvested as soon as possible in these stands. Two harvest cuts spaced 5 to 10 years apart will usually be required so that residual density is not reduced below the C level. (Removal of the paper birch will reduce the mean stand diameter considerably so that much less basal area is required for C-level stocking.) Occasionally—when the present stand is not much above the B level—a delay of 5 years or more may be desirable to build up the basal area enough to permit the first harvest cut without reducing residual stocking below the C level. Where needed, this delay should occur before the first cut rather than between the two cuts because older paper birch often deteriorates after the stand is opened up. After the paper birch has been harvested, the stand should be managed under the northern hardwood or spruce-fir guide, as appropriate.

PRESCRIPTION K. If a reasonably good seed year is not expected, cutting should be postponed until a better seed crop is expected, or the stand should be regenerated by using narrow strip cuttings to optimize the environment and reduce dispersal distances. See pages 16 to 17. If there is a nearly complete lack of paper birch seed trees, direct seeding should be employed in addition to strip cutting. See page 19.

PRESCRIPTION L. Where site conditions are expected to be severe for regeneration, either strip cutting or seedbed scarification, or both, will be required. See pages 16 to 19 for discussion of these techniques.

PRESCRIPTION M. Harvest the present stand and regenerate a new one through clearcutting. If large summer clearcuts are planned, leave about four paper birch seed trees per acre. See pages 13 to 15 for details of procedure.

■

Appendix

Table 1.—*Minimum stocking required for various types of management*[1]

Stand size class	Minimum stocking required[2] for management for—		
	Paper birch timber alone	Mixed timber	Aesthetics or other purposes
Seedlings <1.0 inch mean diameter	At least 50 percent of plots stocked with paper birch stems of any type.	At least 50 percent of plots stocked with paper birch stems and the proportion of crop tree species other than paper birch in the stand is at least 40 percent.	At least 50 percent of plots stocked with paper birch stems.
Saplings 1.0 to 5.0 inches mean diameter	At least 50 percent of plots stocked with paper birch crop trees.	At least 50 percent of plots stocked with paper birch crop trees and the proportion of crop trees other than paper birch in the stand is at least 40 percent.	At least 50 percent of plots stocked with desirable paper birch.
Poles 5.0 to 11.0 inches mean diameter	Paper birch crop trees represent at least 50 percent of B-level basal area. Or, the stand is mature and the management objective calls for regeneration to paper birch.	Paper birch crop trees represent at least 50 percent of B-level basal area and there is an equal number of other (long-lived) crop trees.	At least 100 paper birch trees per acre.
Sawtimber >11.0 inches mean diameter	Stand stocking equals or exceeds C level; paper birch represent at least 50 percent of basal area. Or, the stand is mature and the management objective calls for regeneration to paper birch	Stand stocking equals or exceeds C level; paper birch represents at least 50 percent of basal area, and other crop trees represent at least half of B-level stocking.	At least 50 paper birch trees per acre.

[1]Use northern hardwood or spruce-fir guide as appropriate for stands that do not meet these requirements.
[2]Crop-tree specifications are given in table 2. Stocking of seedling and sapling stands is determined from table 3 and stand diagnosis.

Table 2.—*Crop-tree specifications*

SPECIES AND PRIORITY

Paper birch. (First priority).

Yellow birch, white ash, sugar maple, red spruce, white spruce (Second priority).

Beech, red maple, balsam fir (Third priority).

QUALITY

Trees must have good form and be free of defect, insects, and diseases that will prevent them from developing into merchantable trees of at least grade 2 hardwood sawtimber or into softwood sawtimber or pulpwood. Trees with rotten seams, holes, forks, severe crook in the first 17 feet, damaged or defective crowns, sapsucker injury, or similar defects should not be selected as crop trees. Trees perched on rocks or stumps should be avoided. Rootsuckers and stump sprouts should also be avoided if at all possible.

SIZE

To be eligible for selection as a crop tree in previously unthinned seedling or sapling stands, the tree must have a d.b.h. at least as large as the average stand d.b.h. In other stands, the tree should be in the dominant or codominant crown class (intermediate sugar, maple, beech, or spruce may also be acceptable as crop trees in these stands).

Table 3.—*Number[1] of potential paper birch crop trees required in seedling and sapling stands per 113-square-foot plot[2]*

Mean stand diameter (inches)	Number of paper birch required
<0.5	6
0.6–1.5	4
1.6–2.5	3
2.6–3.5	2
3.6–4.5	1

[1]Calculated from tree mortality rates in unmanaged stands on the assumption that desired stocking should be 387 trees at mean stand diameter of 5 inches to correspond to B-level stocking at that diameter as shown in figure 3.

[2]Stocking is the proportion (percentage) of plots that meet requirements shown here. For example, if 82 of 100 plots in a stand of 0.6 to 1.5 inches average diameter have 4 or more paper birch crop-tree stems, the stand is 82 percent stocked.

Table 4.—*Schedule of intermediate treatments*
(At stand age, in years)

Treatment	Management objective									
	Paper birch sawlogs and veneer logs		Paper birch boltwood		Mixed timber of high-value products		Mixed timber of high-value products where clearcutting is not desired		Paper birch for aesthetics	
	Site 70+	Site <70	Site 70+	Site <70	Site 70+	Site <70	Site 70+	Site <70	Site 70+	Site <70
Cleaning	5–10*	—	5–10*	—	5–10*	—	5–10*	—	5	5
Pruning	—	—	—	—	15–20*	—	15–20*	—	(**)	(**)
Precommercial thinning	25	30*	25	30*	25	30*	25	30*	10	10
Precommercial thinning	35	—	—	—	35	—	35	—	15	20
Fertilization	—	—	—	—	—	—	—	—	15	20
Thinning	45	50	35	50	45	50	45	50	(**)	(**)
Thinning	55	60	—	—	55	60	55	60	(**)	(**)
Harvest (paper birch)	65	70	45	60	65	70	65	70	100	80
	Clearcutting, seed tree cutting, or strip cutting		Clearcutting, seed tree cutting, or strip cutting						Small patch cuttings	
Thinning					85	95	85	95		
Thinning					100	115	100	115		
Harvest (other hardwoods or spruce)					120	135	120	135		
					Clearcutting, seed tree cutting, or strip cutting		Patch or shelterwood cuttings			

*Use these cultural treatments only if stand conditions require them. See prescriptions.
**As necessary to maintain health and vigor of trees, prevent insect or disease attack, and maintain appearance desired.

Table 5.—*Expected rotation ages and sizes*[1] *for stands under management*

Species and objective	Paper birch site index (height at b.h. age 50)	Average diameter[2]	Age
	Feet	*Inches*	*Years*
Paper birch, sawtimber	50	9	75
	60	10	70
	70	11	65
Paper birch, boltwood	50	8	65
	60	9	60
	70	9	45
Paper birch, aesthetics	50	9	80
	60	11	90
	70	14	100
Other hardwoods, sawtimber	50	11	135
	60	14	135
	70	15	120
Spruce-fir, pulpwood	50	8	75
	60	8	70
	70	9	65
Spruce only, sawtimber	60	13	135
	70	14	120

[1]See also table 6.
[2]Average diameter of the species shown—not of the entire stand.

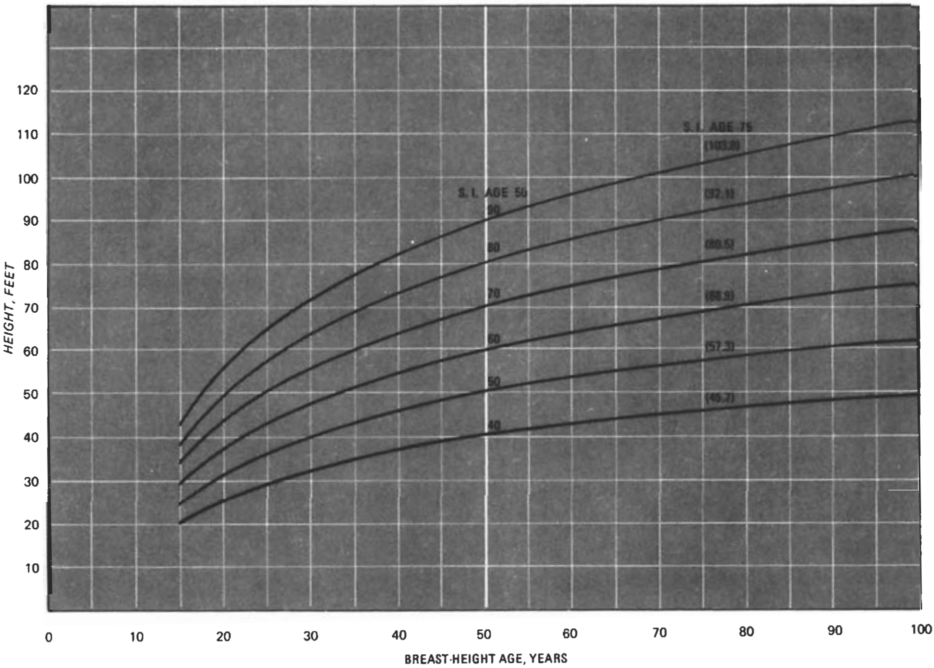
Table 6.—*Merchantable volume yields per acre for stands of various mean diameters, and years to reach various mean diameters by site index (breast height age 50) for pure paper birch stands under intensive thinnings or no thinnings*

Mean diameter[1] (inches)	Merchantable volume per acre[2]	Site index 50		Site index 60		Site index 70	
		Unthinned	Thinned	Unthinned	Thinned	Unthinned	Thinned
	Cubic feet	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*
5	900	43	34	35	28	27	22
6	1,390	53	42	43	34	33	26
7	1,870	65	52	53	42	38	30
8	2,560	79	63	62	50	47	38
9	3,170	95	76	75	60	58	46
10	3,830	—	89	90	72	70	56
11	4,240	—	—	—	86	85	67

[1]Trees 0.6 inches +.

[2]Merchantable volumes for site index 70. Volumes for other site indices can be calculated by multiplying the above yields by SI/70. Volumes are to a 3- to 5-inch top d.i.b. Yields from an intensive thinning schedule will double yields shown here.

Figure 6.—Site-index curves, based on breast-height age 50, for paper birch in Vermont and New Hampshire. To convert total age to breast-height age for paper birch, subtract 5 years on site <60, 4 years on sites above 60.



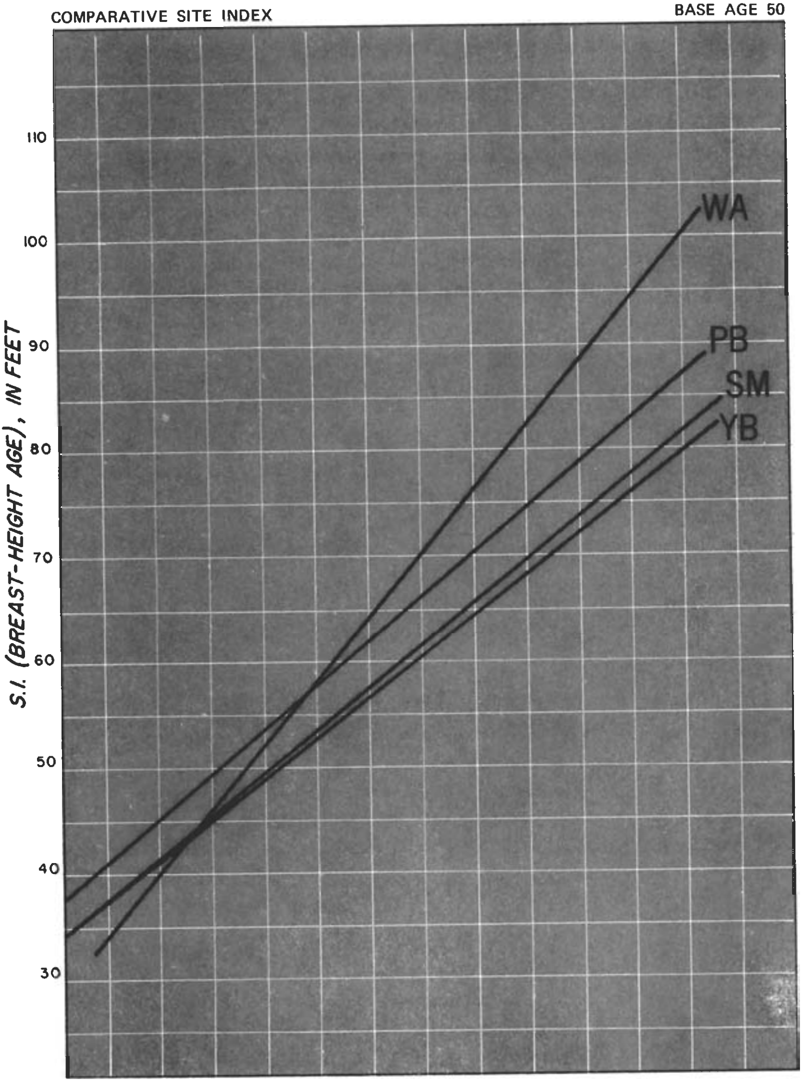


Figure 7.—Relationships among site index for four northern hardwoods. To estimate site index of species X from site index of species Y: find known site index on curve for species Y; move vertically up or down to curve for species X; read horizontally across to the left to find estimated site index for species X.

Figure 8.—Relationship of mean stand diameter to basal area and number of trees per acre for paper birch in the Northeast. The area above the A-line represents overstocked conditions. The area between the A and B lines represents adequate stocking. The area between the B and C lines should be considered as slightly understocked because the stand will return to the B line in 10 years or less. Below the C line is definitely understocked. Only trees in the main crown canopy (dominants, codominants, and intermediates) should be included in stand measurements to be used with this stocking guide.

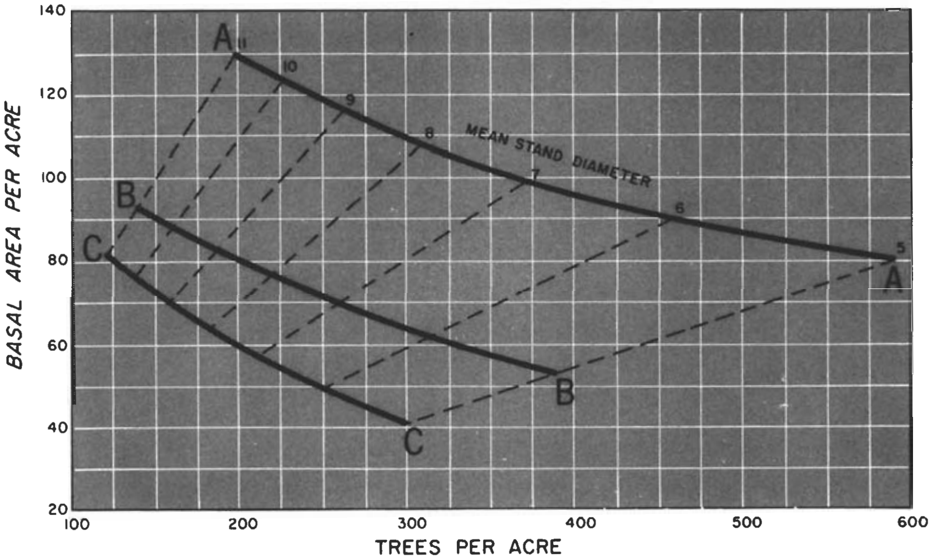
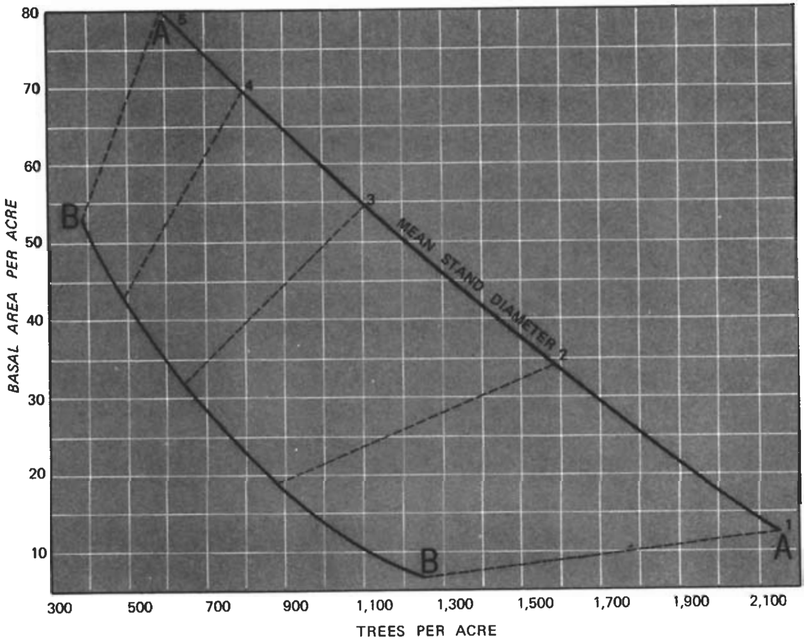


Figure 9.—Relationship of mean stand diameter to basal area and number of trees per acre for paper birch in the Northeast. The area above the A line represents over-stocked conditions. The area between the A and B lines represents adequate stocking.



Tally sheet for stand diagnosis

POLE AND SAWTIMBER STANDS

D.b.h. class	Paper birch crop trees[1]	Other crop trees[1]	Non-crop trees[2]	Total	Conversion factor	No. per acre
2					X458 =	
4					X115 =	
6					X51 =	
8					X29 =	
10					X18 =	
12					X12.7 =	
14					X9.4 =	
16					X7.2 =	
18					X5.7 =	
20					X4.6 =	
Total						
Site-index measurements						$\bar{X}$
Height Age						

Site index _______

No. of plots sampled _______ Average number trees per plot _______

Average No. of trees per acre _______ Basal area _______ Mean diameter _______

Required basal area: B level _______ C level _______ A level _______

Basal area above B level: _______ (available for cut)

Size class of main stand _______ Stand mature? _______

Management objective: ______________________________

Prescription ______________________________

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[1]Trees that meet requirements of table 2 for crop trees, or are merchantable stems of crop-tree species.

[2]Trees that do not meet requirements of table 2 for crop trees, or are unmerchantable even though of merchantable size.

Figure 10.—Sample of tally sheet used for diagnosis of pole and sawtimber stands.

Tally sheet for stand diagnosis

SEEDLING AND SAPLING STANDS

Plot No.	Paper birch crop trees[1]	Other crop trees[1]	Non-crop trees	Total	Stocked ? PB	other
	D.b.h. class <2 2 4 6 8 ε	D.b.h. class <2 2 4 6 8 ε	D.b.h. class <2 2 4 6 8 ε	D.b.h. class <2 2 4 6 8 ε		
Total	(use additional sheets as needed)					
				percent stocked		
Site-index measurements					$\overline{X}$	
Height Age						

Site index _______

No. of plots sampled _______

Average No. of trees per acre[2] _____ Basal area per acre[3] _____ Mean diameter[4] _____

Required basal area for: B level _______ A level _______

Basal area above B level _______

Proportion of crop trees that are other than paper birch _______

Management objective: ____

Prescription: ____

[1] Trees that meet requirements of table 3 for crop trees.

[2] Obtained by multiplying the total number of trees observed by 387 and dividing by the number of plots.

[3] Obtained by multiplying total numbers of trees in each diameter class by the appropriate basal area for that size class, summing over all diameter classes, and then multiplying this result by 387 and dividing by the number of plots. For stems <2 inches d.b.h., use the basal area appropriate for 1-inch trees.

[4] Determined from figure 4, using calculated numbers of trees and basal area per acre.

Figure 11.—Sample of tally sheet used for diagnosis of seedling and sapling stands.

THE FOREST SERVICE of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.