

United States
Department of
Agriculture

Forest Service

Northeastern Forest
Experiment Station

Research
Paper NE-535

1983



Silvicultural Guide for Paper Birch in the Northeast (revised)

L. O. Safford



The Author

L. O. Safford received a B.S. degree in forestry in 1961 from the University of Maine, M.F. degree from Yale University in 1962, and a Ph.D. degree in plant science from the University of Maine in 1968. He joined the Northeastern Forest Experiment Station's spruce-fir silviculture project at Orono, Maine, in 1962. Since 1970 he has been engaged in soil fertility research at the Station's Forestry Sciences Laboratory at Durham, New Hampshire.

Manuscript received for
publication 3 February 1983

Abstract

This revised guide provides practical information on silvicultural treatments to grow paper birch as a timber crop. It covers treatments for existing stands, the regeneration of new stands, and subsequent culture to maturity. The stocking chart has been revised to reflect results of current growth studies.

Introduction

Paper birch has long been prized for its smooth grain and texture, dimensional stability, and capacity for turning and shaping. The numerous small mills scattered throughout the range of paper birch in northern New England rely heavily on this species for the manufacture of numerous items—from toothpicks and pool cues to brush handles, and covers for cosmetic bottles. Because supplies of high-quality birch near these mills are becoming depleted, wood must be transported over longer and longer distances. These conditions drive up the price for birch, which at times is of marginal quality. This guide, a revision of that developed for paper birch by Marquis et al. 1969, describes intensive silvicultural practices that land managers can use to grow high-quality paper birch crops in the shortest possible time. I describe treatments for existing stands with little or no previous silvicultural treatment, the establishment of new stands, and a schedule of treatments from early age to maturity.

Paper birch does respond to treatment. In the greenhouse, with favorable nutrient and moisture supplies, we have grown paper birch to a height of 16 feet and a diameter of 1 inch in 9 months. This growth rate may not be possible under field conditions, but it does indicate the biological potential of paper birch to respond to favorable environmental conditions.

The economics of paper birch growth also are favorable. Since relatively small trees—8 to 10 inches for boltwood and 12 to 14 inches for sawlogs—can be used, a relatively short rotation of intensive treatments can be justified. Land managers can expect a payoff from intensive silvicultural practices in less than 2 decades, as opposed to the many decades required for merchantable size softwoods and many of the other hardwoods. In 1980, the value of paper birch at mills in New Hampshire

ranged from \$105 to \$350 per thousand board feet for sawlogs and veneer, \$70 to \$106 per cord for boltwood, and \$50 to \$70 per cord for firewood.

We anticipate that the application of the cultural measures described in this guide from the time of regeneration to final harvest will reduce sawlog rotation length by half. And working in current stands of pole and near boltwood size will reduce the rotation by several decades.

Paper Birch—The Species

Under natural conditions, paper birch is a pioneer or early successional species. It is intolerant of shade and competition from older trees, woody shrubs, and herbaceous species. Large, pure stands originated in areas burned by wildfire or destroyed by windstorms or other natural disasters. Paper birch can survive and grow on nearly any soil type but as with most trees, it grows best on nutrient-rich, moist sites when competition is not too severe—either by chance or through manipulation of species composition by the forest manager. When growing in mixture with other species, paper birch tends to stand out because of its white bark. The proportion of paper birch is easily overestimated, so careful measurements are required to estimate the proportion of paper birch before one can make silvicultural recommendations for a particular stand.

Paper birch is a fairly short-lived species. Sexual maturity and seed bearing occur at about 15 years of age; the greatest quantities of seeds are produced during the 40 to 70 year age period. By the age of 60 to 90 years, paper birch is fully mature and vigor and quality have begun to decline. Dieback of crowns and death of many trees occurs. Some individuals may reach ages over 100 years with a

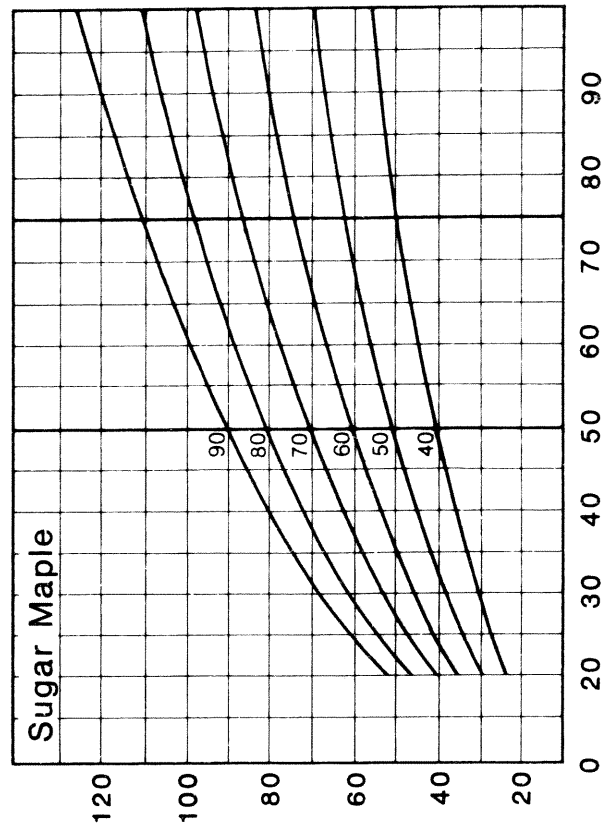
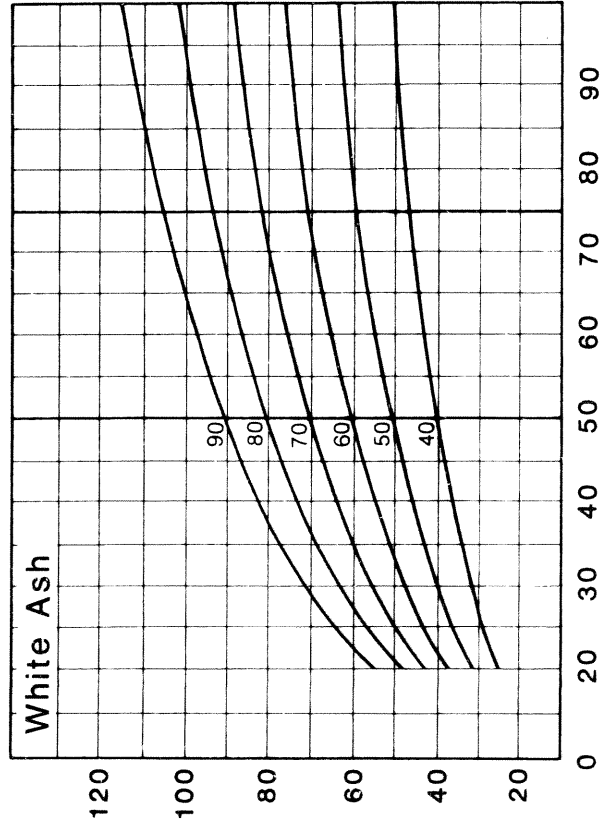
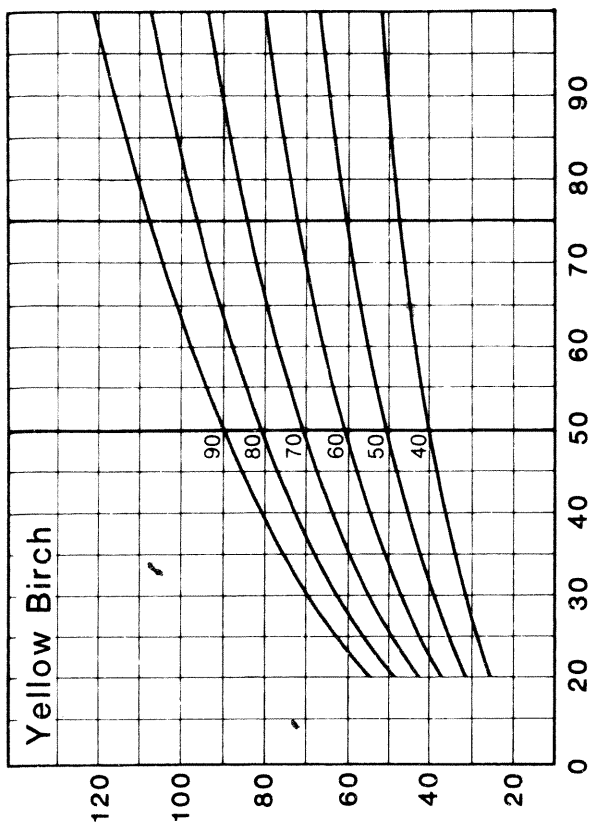
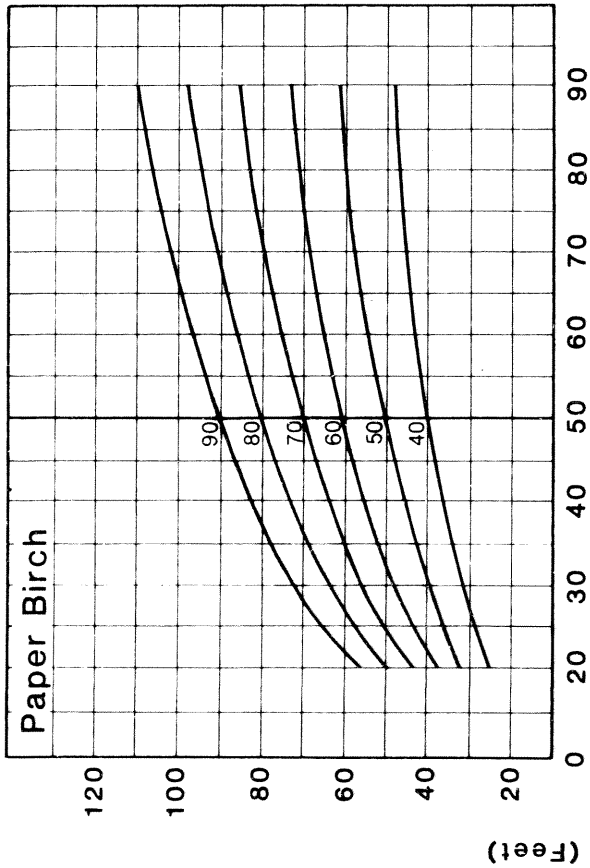
maximum of 140 years. Mountain paper birch (*Betula papyrifera* var. *cordifolia*) lives longer but doesn't attain great size, possibly because of its occurrence at high elevations.

Seed Production and Dissemination

After reaching sexual maturity, paper birch produces some seed nearly every year, a good crop every other year, and a bumper crop 1 year in 10. Seeds ripen in late summer with some dispersal beginning in August and continuing through the winter. Maximum seed fall occurs in September and October before snowfall. Some of the light, winged seeds can be carried great distances by the wind, but the greatest amounts fall within 100 to 200 feet of the parent trees. Paper birch seeds normally germinate in the spring following their dispersal, but recent work indicates that some may be stored in the forest floor for at least 1 year. Majority of seedlings in new stands become established during the first growing season following disturbance, but a small proportion may be added during the second and third years.

Seed Germination

Germination and survival of paper birch seedlings depend greatly on the condition of the seedbed. Mineral soil provides the best moisture and temperature conditions for germination and initial survival. However, nutrient elements are most available from the organic materials in the forest floor. So for establishment and early growth of the seedlings, it is extremely important for the organic material to be preserved in the seedbed. Treatments such as scarification, disking, or light burning help provide the best seedbeds for establishing paper birch.



BREAST-HEIGHT AGE (Years)

HEIGHT (Feet)

Site Requirements

Paper birch becomes established and grows reasonably well on a wide range of soil-site conditions. Intensive culture should be practiced only on sites that are best suited to its establishment and growth. The poorest sites are extremely wet with poorly drained soils, or extremely dry with shallow to bedrock soils or coarse sands and gravels on glacial outwash deposits. The broad range of sites between these extremes generally are acceptable for paper birch, but some may be less suited than others because of the degree of competition from other species and silvicultural requirements to minimize this competition.

Site index (breast height age 50) can be used to estimate the relative productivity for paper birch among sites. Where paper birch is not of sufficient age to estimate site index directly, relative productivity can be estimated from site index of other species in the stand (Fig. 2). The procedure for measuring site index is included in the Appendix. In general, sites with site index of 60 or greater for paper birch are considered satisfactory for intensive culture. Sites with a site index lower than 60 require careful evaluation before large investments of time and money are made. Under some management objectives and resources, intensive culture may be justified. For example, on readily accessible land close to a mill or other market, it might be economically feasible to apply silvicultural procedures that would raise site index from 55 to 60, 65, or higher.

Figure 2.—Relationships among site indexes (base age 50) 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 of species X; read horizontally across to the left to find estimated site index for species X.

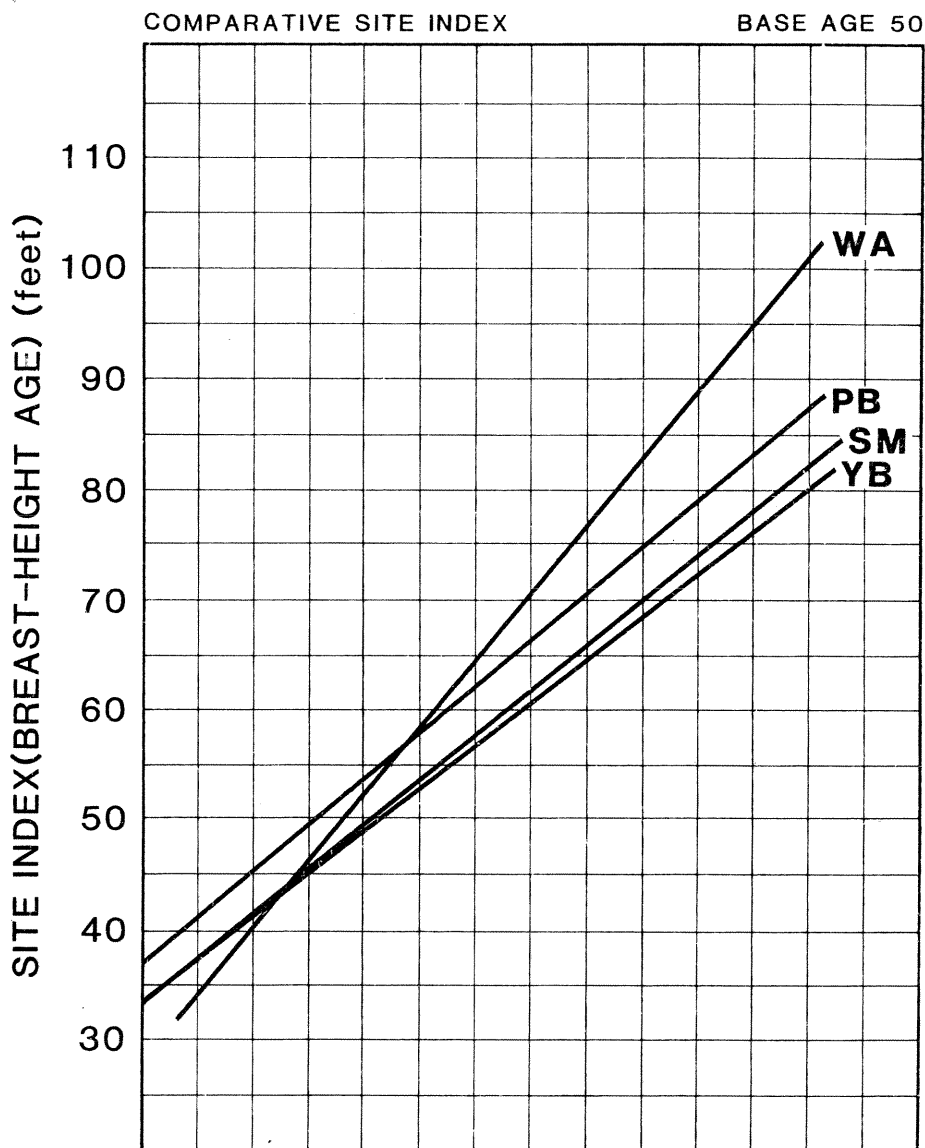


Figure 1.—Site-index curves (breast height age 50) for paper birch, white ash, yellow birch, and sugar maple in Vermont and New Hampshire.

Principal Enemies

Discoloration and decay seriously reduce the quality of paper birch. Branch stubs provide the major avenue of entry for microorganisms that cause these defects. Trees maintained in a vital, fast-growing condition will rapidly close branch stubs resulting from natural branch shedding or wounds made by pruning. It is important to create conditions that confine the discolored and potentially decayed portion of the tree to as small a central core as possible. This is done by encouraging early natural shedding or proper pruning (Fig. 3) while branches are small and the diameter of the bole is 4 inches or less. This will minimize the volume of potentially defective wood and confine it to the interior portion of bolts and veneer logs.

Paper birch is sometimes infected with root pathogens that cause a defect called collar crack. Growth is reduced and foliage may become sparse and pale. Root-damaged trees are easily uprooted by the wind. Stem wounds caused by fire, logging, or falling trees become infected, resulting in a central column of discolored wood that is susceptible to decay. The column of diseased wood equals the size of the tree at the point and time of injury (Fig. 4). Also, stem cankers that ruin trees for timber purposes

and make them unsightly for esthetic purposes are often caused by fungi that first infect branch stubs (Fig. 5). Paper birch trees with these conditions will continue to deteriorate, and should be removed from the stand. If the sources of infection cannot be eliminated, some stands may have to be completely regenerated, or converted to other species.

Several insect pests cause various degrees of defoliation of paper birch by eating foliage or mining the interior contents of leaves. Defoliation causes growth rates to decrease during years when it is severe. Dieback in the top or mortality may result if complete defoliation occurs for 2 or more years in succession.

Insects such as the bronze birch borer cause defects in the bole wood by tunneling and mining. These defects decrease the quality of the wood, though healthy trees are seldom killed.

The yellow-bellied sapsucker damages paper birch trees by pecking holes through the bark to the cambial region. This often results in discoloration and ring shake. Severe sapsucker activity can ruin the quality of merchantable-size trees and may result in mortality. Many of the dead

portions in the crowns of mature paper birch are the result of sapsucker feeding.

Deer browsing can hinder early height growth of paper birch. This can be particularly serious in areas reproduced by sprouts or planted seedlings. Unless browsed severely enough to result in mortality, the trees eventually grow beyond the reach of deer and stem form recovers. Deer seem to prefer pin cherry as a browse source. Since pin cherry is a common associate of paper birch in regeneration stands, cleaning and weeding operations to remove it should be delayed until the birch has grown beyond the reach of deer (4 to 5 feet in height).

Natural regeneration usually is sufficiently abundant to withstand normal amounts of damage without consequence to the establishment of stands. In areas with marginal quantities of natural regeneration or in birch plantations, clipping of seedlings by snowshoe hare and girdling by mice can be a significant cause of seedling death. Some protection from animals may be required. The forest manager should consult with local wildlife authorities on appropriate control techniques.

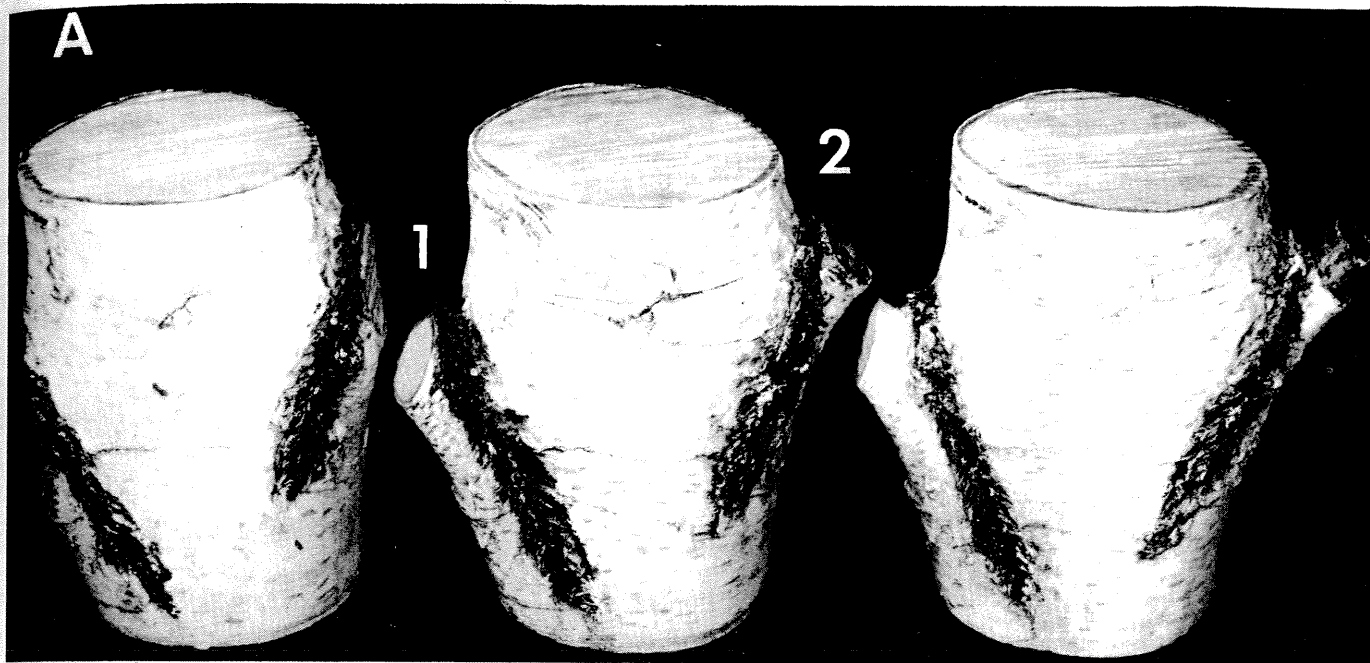


Figure 3.—Guidelines for pruning paper birch: (A) Three views of a stem segment of paper birch showing correct pruning of a live branch (1) and dead branch stub (2). The center segment is correctly pruned. Branches were cut too close on left segment and too long on right segment. (B) Longitudinal section of a paper birch stem and branch showing proper and improper location of pruning cut.

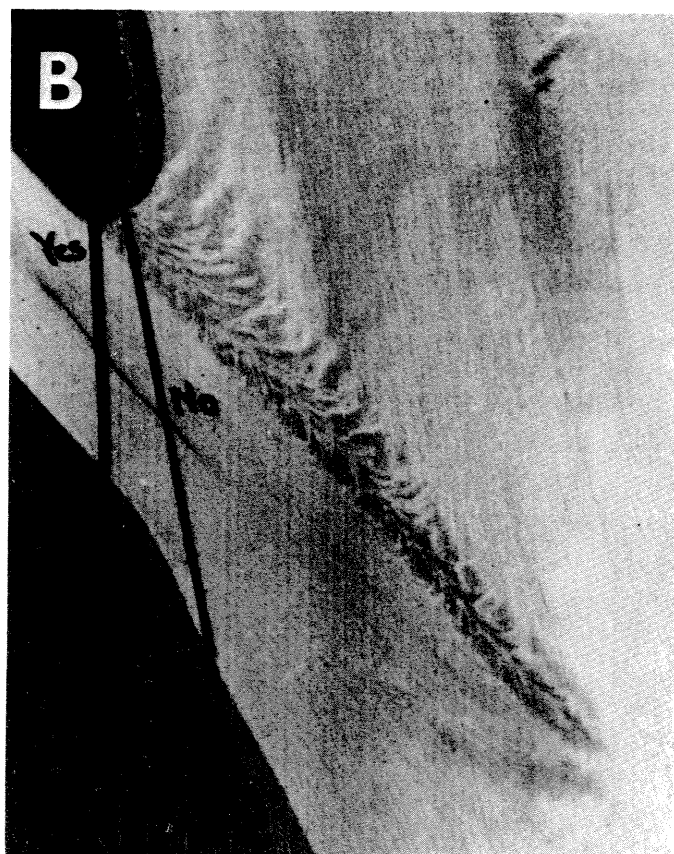


Figure 4.—Dissection of a 100-year-old paper birch tree with a basal wound made by logging or fire 50 years ago. Column of completely decayed wood in the lower stem portion (right) plus the column of discolored wood in the upper stem portion (left) equals the size of the tree at the time of injury.

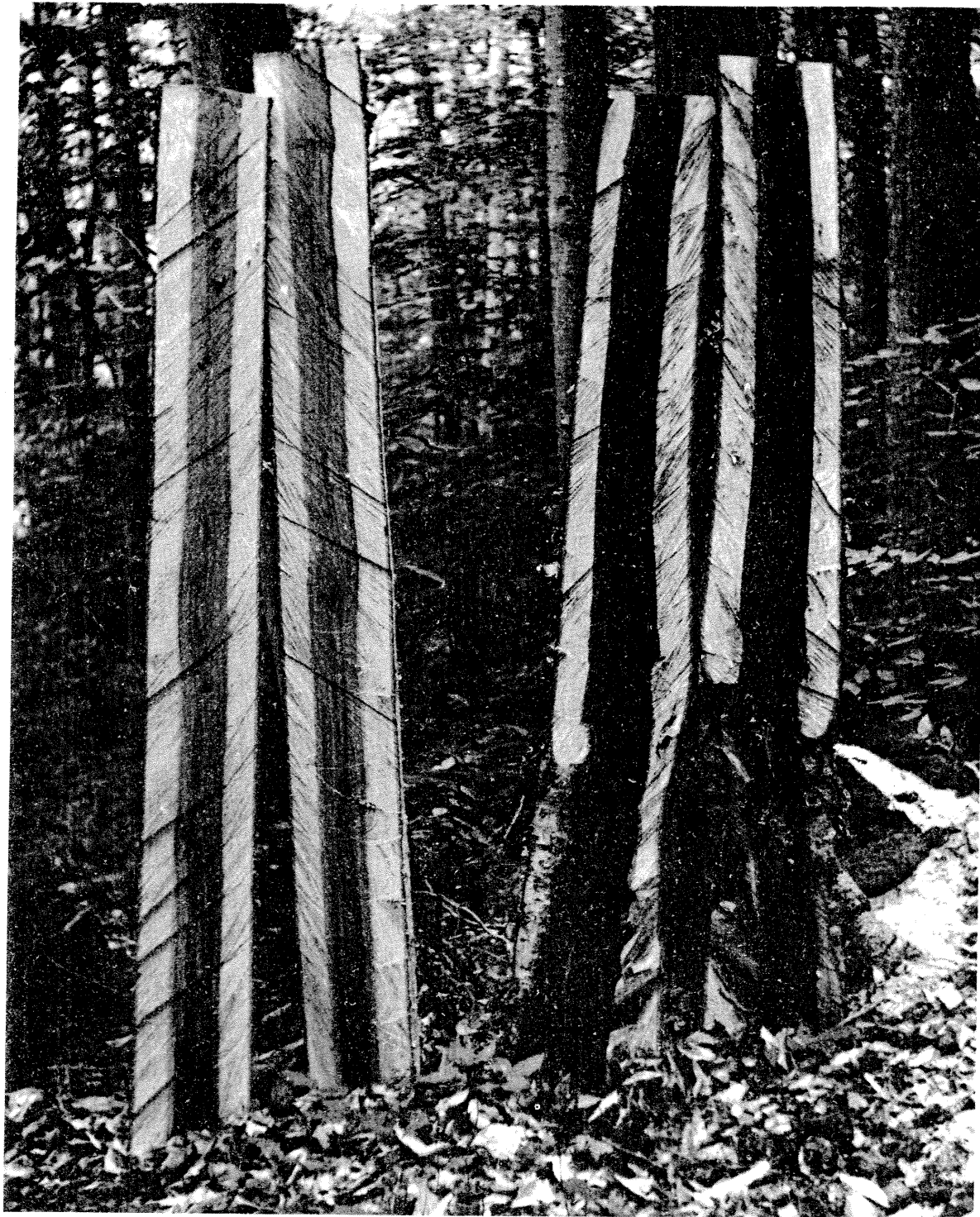


Figure 5.—(A) Sterile conk of *Poria obliqua* on paper birch. The margin of the hard mass of fungus material usually pushes into the bark around the tree rather than above and below the wound. Swollen stems result from such cankers. (B) Dissection of a paper birch, showing the black sterile growth of *Poria obliqua* on a stem stub and the column of discolored wood associated with it.



Management Objectives

This guide assumes the objective of producing high-quality paper birch as a timber crop. Boltwood, sawlogs, and veneer logs are the primary products sought in the intensive culture of paper birch stands. Products of lower value, such as firewood or pulpwood, may be secondary products, particularly of earlier thinning operations. Some species other than paper birch may be included in the stand, but these too should have potential for high-value products. Any stand without sufficient quality potential for high-value paper birch products should not be managed as a primary paper birch stand. This point should not be lightly taken. If the stand cannot be managed as a paper birch stand, it might qualify for a mixed stand of other hardwood species, or even softwood species. It would be shortsighted to liquidate an immature stand of any species in the pole or small sawtimber stage at a time when those trees are making their greatest growth in value.

In addition to its value as a timber tree, paper birch adds to the beauty of roadsides, campgrounds, and other intensively used outdoor areas. Management of individual trees or small groups of trees for aesthetic purposes is not differentiated in this guide, though the same ecological principles apply.

Levels of Management Intensity

The overall management goals are to improve yields and quality of the growing stands to maximize returns from the final crop. In **intensive** management, the developing stand is molded from a young age to contain sufficient growing stock of the very best possible quality trees to fully occupy the site. The manager selects and releases the growing-stock trees on the basis of species, stem form, and stem size (an indication of relative growth rate), and applies cultural practices such as pruning and protection from injury to

minimize defects. Site improvement techniques such as liming and fertilizing also can be applied. Intensive management starts at a young age and continues throughout the rotation by frequent observations of stand conditions and applications of silvicultural treatments as needed.

The available resources, site, or stand conditions often warrant less intensive practices than those described. In these cases, **medium intensity** management can be practiced. Although these treatments might not start as early or be as frequent as intensive practices, their aim is to maximize the numbers and quality of birch stems in the stand. The single most important operation is examining the stand during or before the sapling stage to determine if there will be a sufficient number of quality birches to ensure a satisfactory birch component at maturity. Some stands can develop without early release work; others will require release of the birch or its status in the stand will diminish and management for birch will not be possible. Additional work can be postponed until a marketable product such as fiber, fuelwood, or pulpwood can be harvested to help pay for the treatment.

Low intensity management—or no management at all other than final harvest and regeneration—may be the proper choice on poorer sites. Steep slopes, roughness, and poor soils hinder silvicultural treatment and push costs beyond economic returns. Stands approaching maturity that have not been managed might not benefit from or respond to treatment. Perhaps only one preharvest improvement cutting or thinning to remove least desired species and salvage declining birch would be warranted in these situations. About the only “intensive” management possible in such a situation would be careful planning of the logging operation and marking of trees to minimize damage to the residual stand.

Management Strategy

In addition to the high-value birch product objective already discussed, the management strategy includes two other components: silvicultural requirements of the species and economic considerations. These are integrated to form the management strategies which, in turn, govern the management activities chosen.

Silvicultural treatments concern species composition of the stand and the degree in which paper birch predominates. **Pure stands** are managed with the primary silvicultural treatments directed entirely toward the paper birch component. Although stands as low as C level (Fig. 10) stocking in paper birch can be managed as “pure,” a birch component at the B level or higher will give the greatest yields and response to treatment. In these stands, all silvicultural treatments are applied to meet the requirements of the paper birch component. Other species that may be present are given less consideration.

In **mixed stands**, other valuable species are grown along with the paper birch as a component of the stands. Although paper birch still constitutes at least C-level stocking, silvicultural requirements of these other species are considered when treating the stand. Some birch might be removed to favor development of high-quality stems of other species, and the rotation might be carried beyond the age when paper birch would be regenerated in a pure birch stand. In fact, in most cases, the manager would have the option of converting to a longer rotation of the more tolerant, longer-lived species like ash, yellow birch, sugar maple, and beech when the paper birch matures and is harvested.

In **other stands**, less than C-level stocking of paper birch, the birch can be grown in association with lower value products like fuelwood or pulpwood. The fact that paper birch boltwood has high value at smaller sizes allows it to be grown on a short rotation along with species of pulpwood quality. The presence of birch in the stand in proportions as low as 10 to 20 percent of the basal area

Site and Stand Evaluation

may effectively increase value per acre and allow some silvicultural treatments to the whole stand that otherwise would not be economical. This situation is of particular value to the small woodlot owner who is growing his own fuelwood or producing even a small volume of high-value material of other species. Paper birch serves as a cash crop analogous to the small plots of tobacco grown on many small farms throughout the South.

Economic considerations fall into two categories: (1) producing raw material for a manufacturing process, or (2) maximizing financial returns from a forest property. In the first case, the landowner also may own a business that requires a particular type and quality of roundwood for its operations—birch boltwood for a dowel or spool manufacturer for example. All forestry operations will be applied to maximize the quantity and quality of this specific product. Thus, the value of the manufacturer's product governs the value of the roundwood and may justify a larger timber management investment than for wood sold on the open market.

In the second case, the economic objective might be to provide sustained even income from the forest property. Paper birch and other species would be treated to maximize growth potential and quality for the entire forest property while sustaining sufficient growing stock for continuous production. Another choice might be to "cash in" on paper birch to maximize current income and at the same time minimize impacts on long-term income. This implies a heavier cutting in the paper birch component than would be recommended in the previous case, and perhaps converting from pure paper birch to a mixed stand with a paper birch component.

In all cases, the role of paper birch is governed by the fact that it is a fast-growing, early-maturing species of high value that can respond to treatment and provide economic returns in a relatively short time.

The first step in establishing management programs is to evaluate site and stand conditions. The manager already may have his objective and goal clearly in mind and wish to determine if a specific stand can be managed to achieve this goal. Or he may use site and stand evaluation techniques to search out suitable stands from among those available to him. Or, as will be most common, the landowner/manager may want to assess the qualities of a specific site/stand situation to determine the most appropriate management options. In any case, the manager needs to obtain information about site and stand conditions—both general and specific—on which to base his decision.

The following sections provide guidelines and techniques for gathering and evaluating site and stand data for these purposes. The information is based on past experience, research data, and general knowledge of site and stand conditions in the Northeast. The use of these guides and recommendations requires a certain amount of judgement and flexibility on the part of the user.

Site Evaluation

The first step in deciding a course of action is to examine the area being considered for treatment. The first look should be a general reconnaissance to determine the stand boundaries, total area involved, and general uniformity of site and vegetation. Site characteristics can be evaluated in two categories: (1) those affecting operability, and (2) those affecting biological productivity of paper birch and other species. The former includes accessibility, proximity to markets, and soil properties—including steepness of slope, degree of stoniness, and wetness—that could hamper silvicultural operations. The biological aspects include the soil, climatic, and other environmental factors that directly affect tree growth.

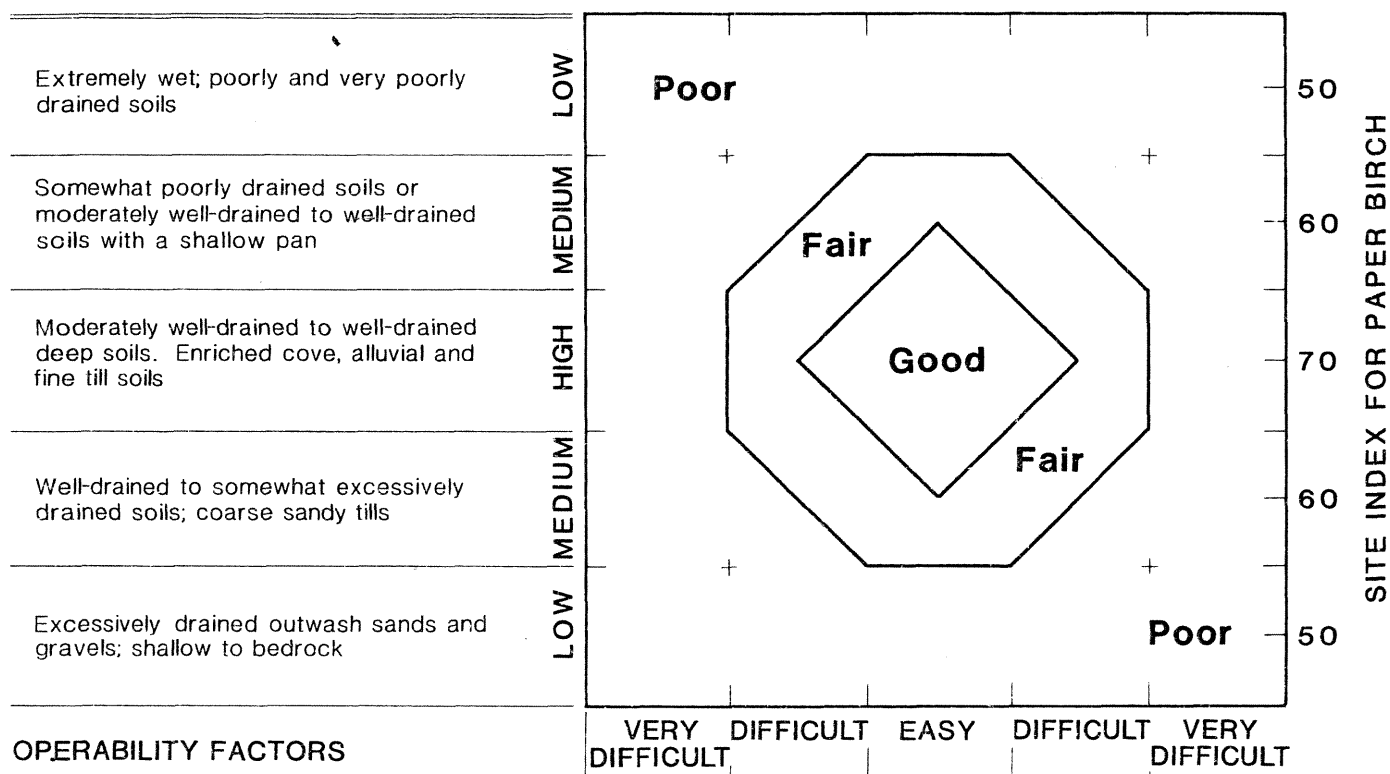
Guidelines from Figure 6 can be used to rank a particular site in relation to the standards prescribed, and to compare two or more potential sites. The manager's judgement determines how much weight each of the factors carries for his particular situation. Strength in one area may compensate for weakness in another area in some cases, but not in others.

Sites ranked as "good" will have minimum management limitations and the widest choice of options for management practice. Sites ranked with "poor" suitability have one or more strong limitations to management practice. This will reduce the management options possible on that site, but some form of management may be possible if the limitation can be

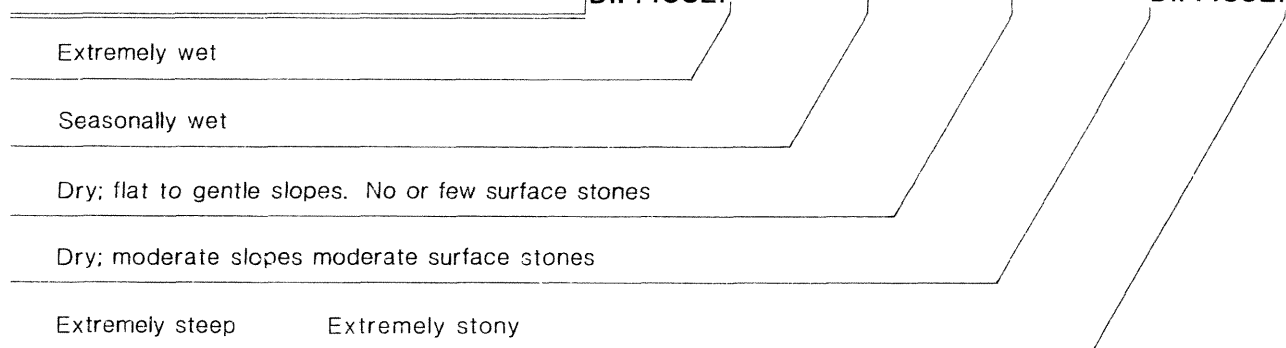
overcome. Sites in the "fair" category have some degree of limitation to management, but the chances for overcoming these limitations are greater and the management options available are greater than for those ranked as "poor."

Figure 6.—Site suitability for paper birch management based on productivity and operability factors. Shaded areas are combinations of operability and productivity factors that are not likely to exist, but would rate poor if they did.

PRODUCTIVITY FACTORS



OPERABILITY FACTORS



Site Index

Site index is the best measure of site productivity currently available. Measurements of site index are required for paper birch or for another species that can be used to predict paper birch. Criteria other than site index should be used to estimate potential productivity of stands that are less than 20 years old. Soil guidelines are provided in Figure 6. When there is a choice among several reproduction stands of equal age (within 2 years), the sites with tallest trees of any species common to all—paper birch, pin cherry, or aspen—would rate relatively higher than the others. Or young stands with trees as tall or taller than those in somewhat older stands probably indicate relatively higher potential productivity.

Again, the owner/manager needs to consider individual practical requirements applicable to his particular situation and management objectives in making the overall assessment of site suitability.

Stand Evaluation

The management stand, or featured stand, dominates the site—or in reproduction stands can be made to dominate through cleaning or weeding—as a continuous cover of dominant and codominant individuals. Species other than paper birch usually become established as understory trees and start to enter the management stand from below toward the end of the rotation. These trees need to be recognized in the overall management picture of older stands, but they do not enter into computation of growing-stock levels when making decisions for thinning and other silvicultural treatments in the main or featured stand.

Stand Diagnosis

The first step in stand evaluation is to measure species composition and stocking level of the stand. The data needed are number of trees and/or square feet of basal area per acre for each species or species group. The proportion of plots with sufficient trees or basal area determines degree and uniformity of stocking.

Reproduction Stands

Reproduction stands have a mean stand diameter of 1 inch or less (0–1.5 inches). They are best evaluated by establishing a number of milacre (6.6 by 6.6 feet square or 3.7-foot radius circular) plots uniformly distributed over the area. At least 20 plots should be measured in stands of 10 acres or less and at least 1 plot per acre in larger areas. Observe and count the potential crop trees of paper birch and other desired species on each plot. Also, observe and count species that are overtopping the birch or threaten to dominate it.

Consider a plot stocked with paper birch if it has at least two vigorous free-to-grow birch seedlings or three vigorous seedlings that need release. Consider the tallest, best-formed paper birch on the plot when making the free-to-grow judgement. Visualize an inverted 90° angled cone with its apex resting on the top of the candidate tree. If the crowns of nearby trees interrupt this cone, the tree needs release. If not, it is free to grow (Fig. 7). Grasses also cause severe competition for paper birch. Consider any birch on plots dominated by grasses as needing release and note this under "Remarks" on the tally form. Paper birch stump sprouts may be present in regeneration stands. A stump with one or more sprouts would qualify a plot as stocked with paper birch, but it should be tallied as needing release even if sprouts are taller than the other vegetation.

Final data will be a summary of percent of plots stocked with (1) free-to-grow paper birch, (2) potential crop paper birch not free to grow, and (3) potential crop trees of other desired species (record species in "Remarks" column); plus percent of plots dominated by aspen, pin cherry, or sprouts of any species (from "Remarks" column). A sample tally sheet is provided in Figure 8.

Sapling Stands

Sapling stands have a mean stand diameter of 2 to 4 inches (1.6 to 4.5 inches). The plot size and tally form for seedling stands can be used. Consider a plot stocked when it has one free-to-grow potential crop tree or two potential crop trees that need release. If more than 20 percent of the plots contain aspen or red maple stump sprouts, release will be required to maintain dominance of paper birch in the stand.

Pole and Sawtimber Stands

Stands with a mean stand diameter of 5 inches and larger (4.6 inches and larger) can be evaluated by variable plot point sampling techniques with a 10-factor prism. All trees in the featured stand—dominants, codominants, and intermediates reaching the main crown canopy—are tallied by diameter class, species, and condition—acceptable (potential crop tree) or unacceptable. Figure 9 is a sample tally form.

This tally sheet can also be used to evaluate the effects of various thinning options and to formulate marking rules. Thinning or partial harvest cuts can be simulated by subtracting trees to be cut from the tally sheet and determining the new stocking level for the residual stand. Make up a new sheet, omitting those trees that you believe should be cut to achieve the desired releases of the birch crop trees. For example, if the stand is approaching maturity with no previous treatment, removing low-quality trees and undesired species might be a good management choice. Go over the original tally form and retally, omitting these trees. This will give the new number of trees, basal area, and mean stand diameter of the post-treatment stand. Then the stocking guide can be used to judge if more or fewer trees should be removed.

Figure 7.—Illustration showing a reproduction stand (mean stand diameter of 1 inch or less) of paper birch needing release. Trees 2, 4, 9, and 13 are potential paper birch crop trees. Only tree 4 is free to grow; the others need release. Trees 3, 6, 8, and 10 are paper birch already badly overtopped and are not potential crop trees. If these were sugar maple, beech, or softwood, they could be considered for release. A minimum cleaning would remove trees 1 (red maple sprout clump), 7, 12, and 14. Trees 3, 5, 6, 8, 10, and 11 would act as trainers to affect branch shedding from the crop trees. A complete weeding would remove all but the crop trees, and some pruning might be required to maintain stem quality.

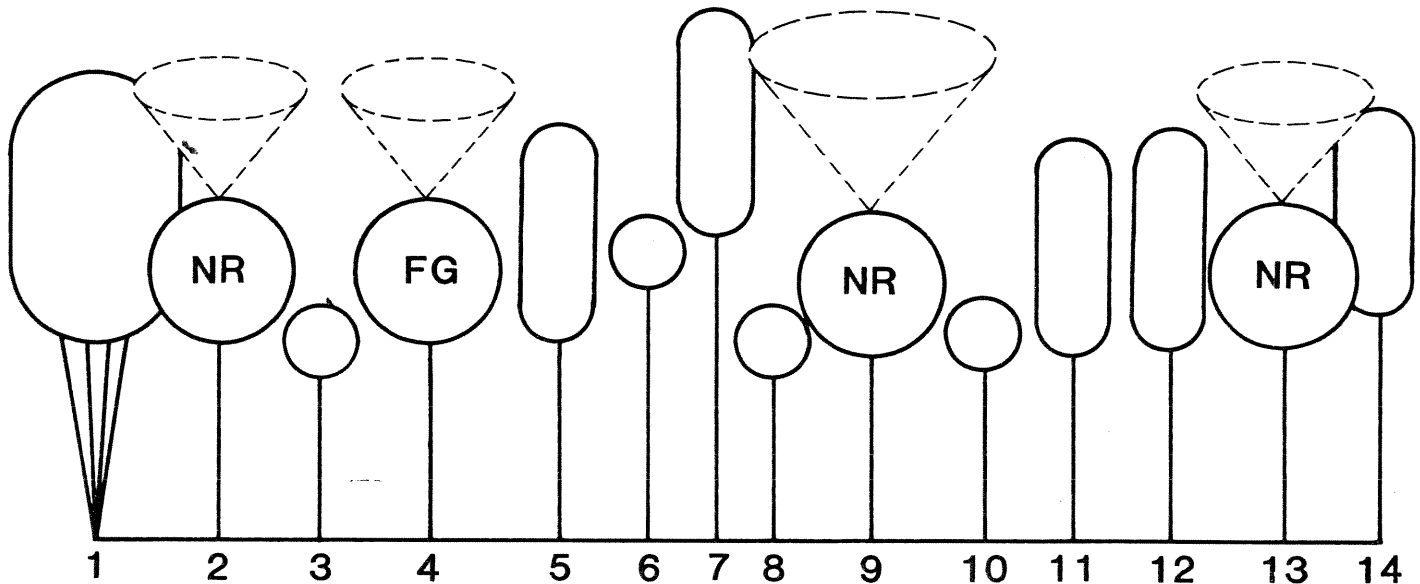


Figure 8.—Sample diagnostic tally sheet for seedling and sapling stands of paper birch.

Plot no.	Paper birch crop trees				Other crop trees				Remarks*
	Free to grow	Need release	Remove trees	X +	Free to grow	Need release	Remove trees	X +	
	No. Stocked?	No. Stocked?	No. Stocked?		No. Stocked?	No. Stocked?	No. Stocked?		
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
Total									
% Stocked									
Trees per acre									

Milacre plot = 6.6 by 6.6 feet or 3.7-foot (3 feet 8 inches) radius

% stocking = No. of plots stocked ÷ total plots X 100.

No. of trees per acre = total no. trees ÷ total no. of plots X 1000

X = No. of single stems to remove to release at least two crop trees.

+ = No. of sprout clumps to remove to release at least two crop trees.

* Record species of other crop trees, plots dominated by grass, aspen, pin cherry or sprout clumps.

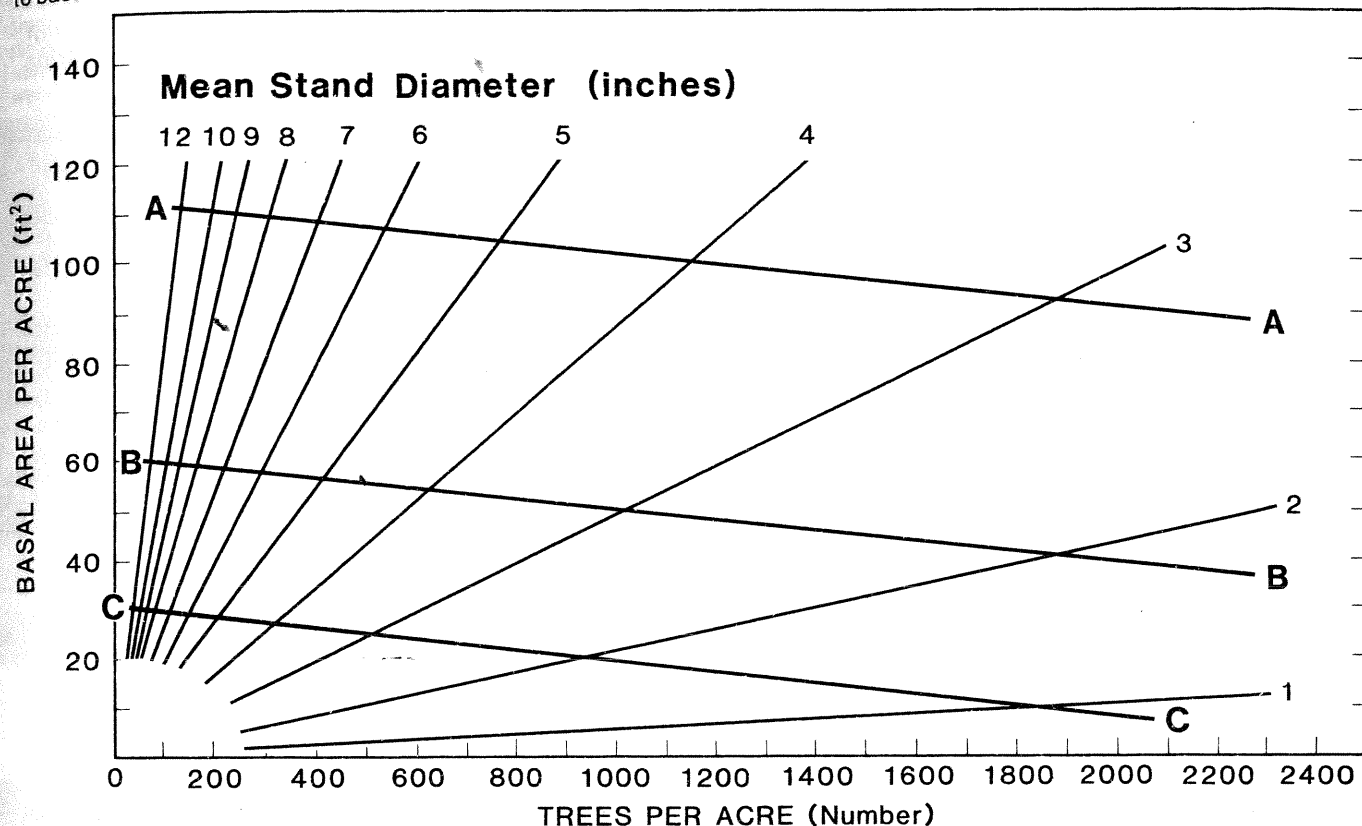
Figure 9.—Sample tally form for pole- through sawtimber-size stands.

Dbh Class	Species					Total		Remarks
	Paper birch	Other desired hardwood	Undesired hardwood	Desired softwood	Undesired softwood	Desired	Undesired	
2								
4								
6								
8								
10								
12								
14								
16								
18								
20								
22								
24								
Total								

Number of points tallied: _____
 For each species diameter class: Divide number of trees tallied by number of points tallied and look up trees per acre in Appendix II. Basal area per acre equals 10 times number of trees tallied divided by number of points tallied. Obtain appropriate totals by species and diameter class.

SUMMARY		STAND DESCRIPTION		All Desired Species	
		Basal area	No. per		
		per acre	acre		
Paper birch		_____	_____	No. trees per acre	
Other desired hardwoods		_____	_____	Basal area per acre	
Desired softwoods		_____	_____	Mean stand diameter	
Total desired		_____	_____	Basal area at A level	
Undesired hardwoods		_____	_____	Basal area at B level	
Undesired softwoods		_____	_____	Basal area at C level	
Total undesired		_____	_____		
				STAND PRESCRIPTION	

Figure 10.—Stocking guide showing relationship of mean stand diameter to basal area and number of trees per acre for paper birch in the Northeast.



Stocking Guide

Young stands of natural reproduction contain large numbers of small trees per acre. With age, the trees grow larger and competition-induced mortality reduces their numbers. The stocking chart (Fig. 10) shows the relationship between number of trees, tree size (mean stand diameter), and stand density (basal area per acre). The area of the chart marked by the A line and above represents the course of development for fully stocked, natural unmanaged stands. Stands with stocking above the A line are considered overstocked.

Individual trees grow slowly and require a long time to progress to the larger sizes of maturity. These fully stocked stands produce the greatest total quantities of biomass. Increasing the growing space available to individual trees by thinning allows the individual tree to grow faster, but may reduce the total production per acre. The aim of management is to maintain the required number of trees of desired species, form, and quality per unit area to maximize total value production of the desired product.

Stands with stocking level at or above the B line are adequately stocked and can fully occupy the site.

Total growth per unit area varies relatively little among stands with basal areas near the B line. The B line represents the stocking level below which competition-induced mortality is minimized.

Depending on the number of quality stems available, thinning treatments can be applied to reduce stocking levels anywhere between the A and B lines. If there are markets for small-size material that would make frequent entries into the stand possible, then each thinning should reduce stocking part way to the B level. For less frequent entries, stocking should be reduced to the B level in one or two treatments.

By their nature as early successional stands, paper birch stands produce light shade. The more tolerant, longer-lived species may become established in the understory and any thinning in the overstory will encourage these invaders. Reducing stocking to the C level or below will allow the invading species to develop to the point that they may interfere with birch growth. Avoid this situation unless the long-term goal is to encourage succession, and convert to tolerant hardwoods, spruce-fir, or pine when the birch is mature.

The C line also can be used to decide whether a stand has enough paper birch to merit treatment as a pure birch stand; that is, if a stand has overstory basal area equal to or greater than C-level stocking in paper birch, it is satisfactorily stocked for management as a birch stand. On the other hand, an open stand that is all or nearly all birch but does not reach C-level stocking probably would not be suited to management.

Regenerating Paper Birch

Paper birch requires large openings and full sunlight for successful regeneration. Clearcutting—harvest or removal of all trees larger than 1 inch in diameter—in blocks up to 40 acres in size, in alternate strips, or small

patches of about 1 acre can be used to regenerate birch.

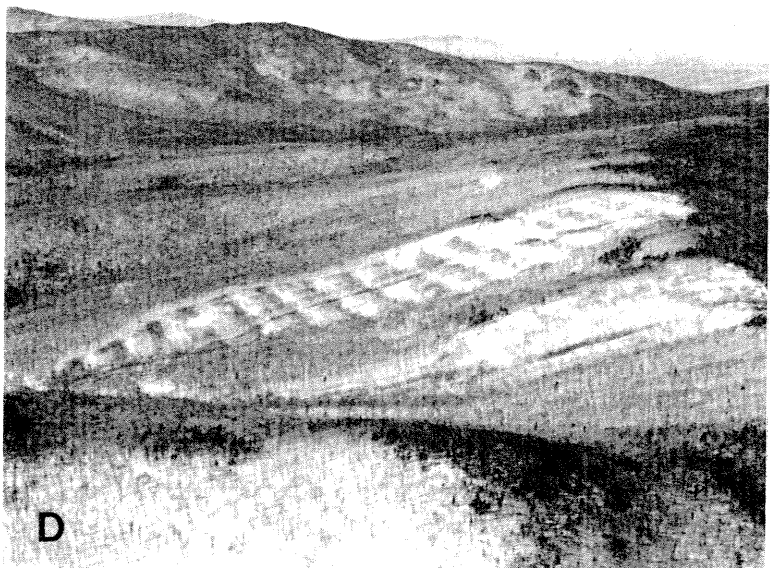
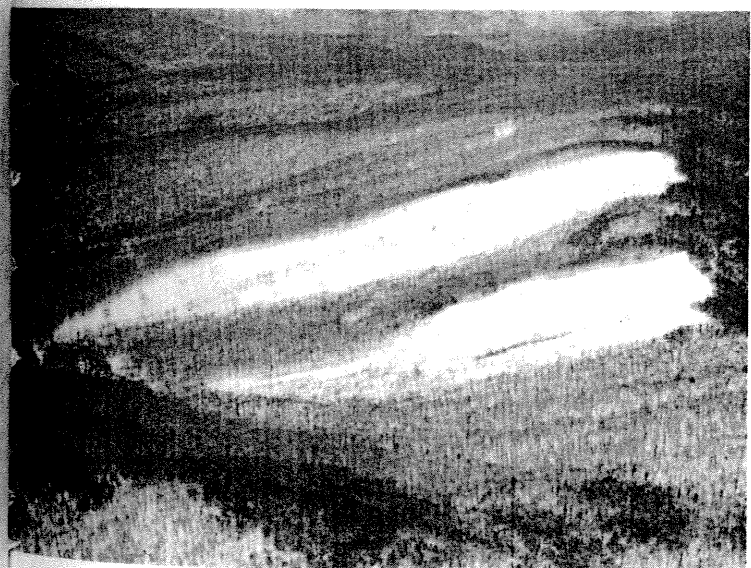
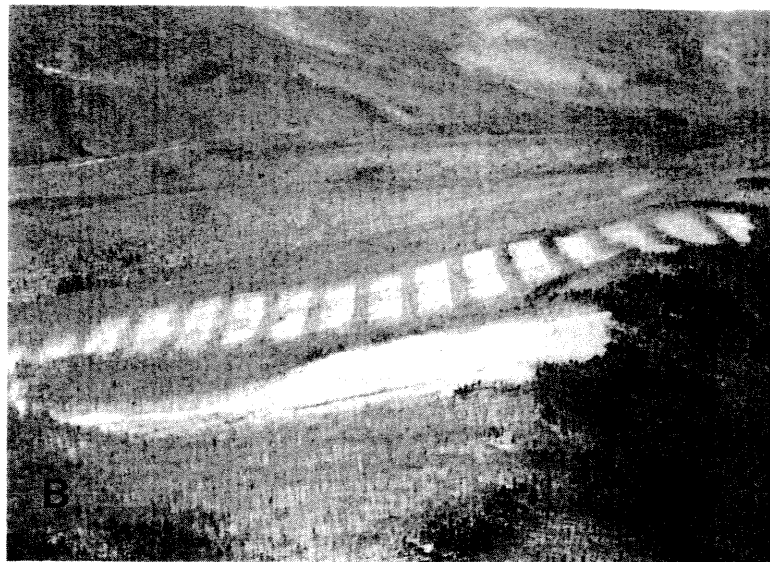
Scarification of the soil by breaking up surface organic horizons and mixing with surface mineral soils provides ideal seedbed conditions for germination and establishment of paper birch seedlings. Logging with modern skidders during seasons when there is no snow and the soil is not frozen provides adequate scarification. In full-tree logging, skidding trees with branches attached ideally prepares the site. There is no slash and nearly 100 percent of the area is scarified without loss of the nutrient-rich forest floor material. Adequate quantities of seed may not be dispersed into cuttings wider than 300 feet for cuttings made during the summer season before seed matures on the trees being harvested. Also, in years when a poor seed crop is expected, it would be good insurance to leave three to five well-distributed paper birch trees per acre. They should be healthy, full-crowned trees capable of producing abundant seed. The seed trees can be removed after two seasons with minimum damage to the regeneration.

Where large clearcuttings are undesirable—on steeper slopes, especially on south- and west-facing aspects, small ownerships, or where a mixture of yellow birch and other

species is desired—cutting in narrow strips or small patches is recommended. In stripcutting, one-third of the area is cut in 50-foot-wide strips oriented in an east-west direction. After 2 or more years, the second third is cut by removing another 50-foot-wide strip on the south edge of the first cut. The final strip is removed as soon as regeneration is established in the second cut area (Fig. 11). This provides the maximum seed source and also protects the developing regeneration during its establishment. Full sunlight and open conditions favorable to paper birch are established when the final strip is cut. This form of cutting gives maximum protection to the site and minimizes erosion potential and leaching of nutrients to streamflow.

Small patches (less than 1 acre) also can be used like strips. 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 retain a paper birch component when combined with uneven-aged management. Patches may be used in special circumstances on very small tracts, roadside areas, parks, or other areas where there is insufficient space for strips or where the esthetic appearance of clearcut strips would be undesirable.

Figure 11.—Aerial view of a progressive strip cutting with a large block clearcutting in the foreground: (A) One-third of the area cut in 50-foot wide strips; (B) Second one-third cut 2 years later; (C) Entire area cut after additional 2 years. Note buffer strip of trees along brook in center of cutting; (D) Area 6 years after initial cut. Note that development of regeneration still shows strip pattern. Block clearcut in foreground also is regenerating well.



Intermediate Treatments

Shelterwood cuttings might also be used where strips or patches are undesirable or impractical, though few research data are available from the Northeast. The first cut should remove 60 percent of the total basal area. The residual stand should maintain at least four to five paper birch seed trees per acre. All trees down to 1 inch dbh should be removed at this time. After a 2-year establishment period, the second cut should remove the remaining overstory. Waiting longer than 2 years for the final cut may result in decadence and loss of value by the residual paper birch trees. Also, the proportion of more tolerant species will be increased.

If the harvested stand contained abundant red maple, beech, or aspen, stump sprouts and rootsuckers will be abundant. Mechanical removal or herbicide treatment will be necessary to prevent domination of the birch seedlings. This treatment might consist of a preharvest stem injection of unwanted species, treatment of freshly cut stumps during the harvest operation, or treatment of young sprouts when the residual trees are removed from the area after the harvest has been completed. A repeat treatment may be necessary within a few years in areas where the undesired species were initially abundant.

Birch stump sprouts can be left to supplement the seedling regeneration. Where there was a high proportion of paper birch, especially if the stand has been previously managed, stump sprouts can provide a quick source of reproduction. Sprouts can be especially important in the small stands and sensitive areas mentioned previously.

Any clearcutting requires precautions to avoid soil erosion and water contamination. Problems can be avoided by proper design, layout, and construction of roads. Careful stream crossings, water bars on skid trails, and seeding of temporary roads and skid trails following cutting should be used. A partially cut (50 percent or less of stand volume) buffer strip should be left along all streams and other significant water courses.

Seeding and Planting

Where paper birch seed source is completely lacking, or where genetically selected parentage is desired, birch seed or seedlings may be planted directly on prepared seedbeds. In direct seeding, best results are obtained by sowing seed at the rate of one million viable seeds per acre on well-prepared mineral soil seed spots 3 to 4 feet in diameter, or on 3- to 4-foot-wide strips, uniformly spaced over the clearcut area. Adding a slow-release fertilizer to the seed spot will stimulate early growth of the seedlings.

Either container-grown or bare-root seedlings also can be planted. Scarification to disturb the surface organic horizons in recent cuttings, and cultivation or herbicide treatment of sodded fields are necessary for satisfactory survival. A herbicide treatment to control competing vegetation for the first 2 to 3 years following planting would be ideal. But, with initial site preparation and 6- by 6-foot spacing, satisfactory stand establishment should be obtained on most sites. Once established, the same intermediate cultural practices will be required for plantations and direct-seeded areas as with natural regeneration (see section on cleaning and weeding).

Once regeneration is established, the manager has the opportunity to mold stand composition and stocking level to ensure the highest proportion of birch and other desired species of the highest quality stems throughout the life of the stand. Treatments begin with cleaning or weeding in seedling and sapling stands, continue with thinnings in the pole and small sawtimber stands, and are completed with the final harvest clearcutting or conversion to management for the tolerant, longer lived species. These treatments reduce competition and increase growing space of selected crop trees, i.e., trees that have potential for providing the final product objective.

Selecting Crop Trees

Paper birch has top priority for selection as a crop tree at all stages. In areas within the stand where paper birch is absent, yellow birch, white ash, sugar maple, or red oak can be selected as second-priority hardwoods depending on local markets. If softwoods are present, red spruce, white spruce, or white pine can be chosen. Third priority would be beech, red maple, and balsam fir. Select at the rate of at least two birch crop trees for each one of other species.

Stem quality is the second criterion for selecting a crop tree. In seedling and sapling stands, relative stem diameter is the best criterion for selecting paper birch crop trees. Select trees with diameters at least equal to mean stand diameter. The larger the diameter in relation to the mean, the better the chances of continued superior growth. A few somewhat smaller individuals of the more tolerant species can be selected if they are otherwise vigorous and full-crowned.

In pole stands and larger, select dominant or codominant full-crowned paper birch crop trees. A few crop trees of more tolerant species can be chosen from the intermediate category, but only if they have full crowns for their positions. The stem should be straight and free of forks and excessive branches for a minimum of 17 feet. There should be no logging wounds or injuries caused by insects or wildlife that will degrade the quality of wood within the merchantable stem. Nor should there be insect or disease damage within the crown that will reduce the growth rate. Avoid unstable trees standing on stumps or rocks.

Cleaning and Weeding

Cleaning removes trees or sprouts that overtop or threaten to overtop the desired crop trees from stands not past the sapling stage. Weeding removes all competing vegetation from the stand whether it is overtopping the crop trees or not. These treatments ensure survival and a dominant position for paper birch. They provide maximum stocking of the highest quality stems, and control spacing and distribution of stems. Cleaning should be done at the earliest possible age before desirable stems are physiologically suppressed and while there is a maximum number of individuals to choose from. The smaller stems are easier to treat.

Cleaning and weeding are done by cutting or treating the trees to be removed with an appropriate herbicide. Since herbicides currently available are nonselective, extra caution is required during application to avoid injury to the released trees. The newer

brush cutting saws are safe and efficient and are probably best for treating large areas. Some crews prefer light-weight chainsaws in sapling and larger stands. Care is required in felling trees of this size to avoid bending over the released birch trees because they are quite limber and susceptible to being buried by the tops of felled trees. Resprouting will be minimal if an appropriate herbicide treatment follows cutting. Cut stems can be treated with a brush, mop, or squirt bottle. In some cases, directed sprays might be used. New and more effective chemicals are receiving Federal labels for use in forestry. The forest manager should consult with a specialist in herbicide treatments to obtain the most up-to-date methods and chemicals available. See Caution on page 28.

The degree of release depends on the manager's objective and the species composition of the stand. If the stand is 80 percent or more stocked with birch with only a few overtopping pin cherry or stump sprouts, selection and release of as few as 100 to 150 crop trees per acre may be sufficient. But if there is a strong aspen or red maple sprout component, complete removal is recommended to establish birch as the dominant species. If red maple stump sprouts are few (10 to 20 per acre), thin some to one or two stems per clump and leave in the stand; if many, remove all and treat the stump with herbicide to keep from resprouting. Otherwise, red maple will be a dominant component of the future stand with little potential for other than fuelwood or pulpwood. Any paper birch stump sprouts that are to remain as part of the stand also should be

thinned to one or two of the best stems to maximize growth rate. The most intensive treatment would be complete weeding to leave a uniformly spaced plantation-like stand of pure birch or birch plus other species (Fig. 12). This kind of treatment requires the greatest investment in time and expense but should provide the largest quantities of high-quality paper birch.

Thinning

Thinning removes trees competing with desired crop trees from stands beginning with the late sapling—early pole class up to the sawtimber class prior to final harvest cut. Thinnings remove trees of poor quality and undesired species from stands not previously cleaned or weeded, and reduce stocking to desirable levels indicated by the stocking guide. Early thinnings may be similar to cleaning in that they remove aspen, pin cherry, or red maple sprouts that are threatening to dominate birch crop trees. Any poorer quality stems and lower crown class individuals of birch or other potential crop species also may be removed in early thinnings. Since this material is small, it is generally not marketed, but potential fiber or fuelwood sales might return at least part of the treatment cost. About 300 to 400 crop trees per acre should be identified and released at about 20 to 25 years of age (Fig. 13). As many as half of these may be other than paper birch if management for a combination of species is desired. Final stocking level should be close to the B line on the stocking guide. In previously untreated stands, two treatments about 5 years apart may be required to reach this level without opening the stand too rapidly.

Figure 12.—A 13-year-old stand of paper and yellow birch that was cleaned and weeded at age 7. About 900 trees per acre remain. Note the dense stocking of pin cherry in untreated stand in background.



Figure 13.—A 47-year-old stand of paper birch with tolerant northern hardwoods in the understory. The stand was thinned once at age 25, releasing 300 to 400 crop trees per acre. Growth differential between control and treated persisted for more than 16 years.



Later thinnings can begin in about 10 years after many of the trees are large enough to be harvested for firewood or pulpwood. Use the stocking guide to determine the level of residual stand required for adequate stocking and remove sufficient numbers of trees to reach this level. First, remove any trees that have been injured or have become diseased since initial selection; any remaining noncrop trees should be removed next. Final removals should be from among other crop trees to provide uniform distribution and free growth of the very best remaining trees that will be carried to the final harvest. Two or three light thinnings spaced far enough apart for a profitable logging operation will give closer control over stand development than a single heavier thinning.

It is not always possible to predict how a given tree will develop, especially at the early stages of stand development. By selecting as many potential crop trees as possible and by making frequent observations, the selection can be narrowed so that the best trees are always favored and early selections that fail to meet expectations can be removed. A generalized treatment schedule for low, moderate, and intensive levels of management is suggested in Table 1.

Fertilization

Paper birch is a nutrient-sensitive species that responds to increased levels of fertility. Research has shown that on many of the medium- to coarse-textured glacial soils of the Northeast, deficiencies of nitrogen and phosphorus commonly limit growth. Adding these nutrients may substantially increase both diameter and height growth of birch and other species in the stand.

Only stands that have received previous cleaning or thinnings should be fertilized. Treated stands should be fertilized 1 or 2 years after a cleaning or thinning so that unwanted trees

Table 1.—Generalized treatment schedule for three intensities of management for high-quality paper birch at various stand ages, site index 60

Treatment	Management intensity		
	Low	Moderate	High
Clean/weed	—	5-10	5
Fertilize	—	—	7
Thin	—	—	10
Fertilize	—	—	12
Thin	—	—	17
Fertilize	—	—	19
Thin, prune	—	20-25	24
Fertilize	—	—	26
Thin	—	—	31
Fertilize	—	—	33
Thin	35-40	30-35	38
Fertilize	—	32-37	40
Clearcut for paper birch boltwood or thin	60	40-45	—
Fertilize	—	42-47	—
Thin	—	50-55	—
Clear cut sawlogs and veneer or remove paper birch and convert to tolerant species (encourage succession)	80	60	45

will not increase their competition with the desired birch crop trees. Response to an application of fertilizer lasts 5 to 7 years, so repeated applications each time the stand is thinned will give the greatest response. If only one fertilizer treatment is planned, make it after the last thinning when trees are larger and putting on their highest value (Table 1).

Recommended fertilizer rates are at least 200 and preferably 300 lb/acre of nitrogen from either urea or ammonium nitrate, plus 100 lb/acre of phosphorus from triple super phosphate. They can be broadcast on the soil surface simultaneously in late fall before the ground is frozen or snow covered or in early spring after snowmelt and before leafout.

Pruning

Paper birch usually sheds its branches without need for pruning. However, in more open stand conditions caused by frequent thinning, some pruning may be desirable. Yellow birch and sugar maple retain branches longer and a few trees of each species may be pruned. Prune only fast-growing trees that have potential for sawlog or veneer-log quality. Potential forks can be eliminated and branches removed to convert otherwise desirable trees into good crop trees. Prune close to but do not remove the branch collar at the base of the limb (use Figure 3 as a guide for proper pruning). Be careful not to injure the stem near the pruning site.

Growth, Yield, and Harvest

Estimates of volume yields under various levels of management and site index greater than 60 are given in Table 2. These yields are for pure paper birch stands. If other species make up more than 50 percent of the stocking, yields will be lower; if less than 50 percent, yields can be higher. Also, material removed in thinning will add to the total production over the rotation. Since we have no experience with intensive thinning schedules over an entire rotation, these figures are only estimates. However, projection of current growth rates indicates that these or greater yields can be achieved.

The final harvest removes all paper birch crop trees. This is either a form of clearcutting and regeneration as described earlier, or conversion to the more tolerant, longer lived species in a continuation of natural succession. In the latter case, the harvest of the birch is a release cutting for sugar maple, beech, yellow birch, or softwoods; future management would follow guidelines in silvicultural guides by Leak et al. 1969, Frank and Bjorkbom 1973, or Lancaster and Leak 1978. In the former case, a new rotation of birch is established and the process begins again.

Table 2.—Minimum yields of paper birch for different management levels on sites greater than site index 60

Stand age years	Management intensity		
	Low	Medium	High
	cubic feet/acre		
20	900	900	1,390
25	1,145	1,380	1,870
30	1,380	1,870	2,480
35	1,630	2,215	3,170
40	1,870	2,480	3,830
45	2,175	3,170	4,240
50	2,480	3,550	—
55	2,865	3,830	—
60	3,170	4,240	—
65	3,500	—	—
70	3,830	—	—
75	4,035	—	—
80	4,240	—	—

Flow Charts for Silvicultural Decisions

To determine if reproduction stands require cleaning or weeding treatments to maximize survival and growth of the paper birch component, use the flow chart for reproduction stands 5 to 10 years old (Fig. 14) to select an appropriate prescription. It is important to make this diagnosis and treatment application as early as possible before the birch is suppressed and while stems are small and easy to remove.

The same flow chart technique helps decision making in pole, sapling and sawtimber stands. Keys to prescriptions for thinning and cleaning in sapling and pole stands are given in Figures 15 and 16. Suggestions for harvest/regeneration cuts are diagrammed in Figure 17.

Prescriptions

The following prescriptions were developed for maximizing yields of high-quality paper birch timber products. The manager should rely on his own judgement and experience to determine how closely a specific recommendation should be followed in light of the unique economic and silvicultural circumstances of each forest property. (See appropriate sections of the text for additional details.)

- A. Allow to develop to the sapling stage without treatment.
- B. Clean or weed to release paper birch and other crop trees of desired species. Manage as a mixed stand using the appropriate silvicultural guide for other species while keeping paper birch free to grow.
- C. Mechanically thin by removing one-half of the stems in strips 5 to 6 feet wide, leaving 5- to 6-foot-wide strips. Within the leave strips, remove all aspen and red maple and red oak stump sprouts and other overtopping vegetation.
- D. Clean by removing aspen, red maple, or red oak stump sprouts.
- E. Clean and thin to release 500 paper birch crop trees per acre, or 250 paper birch and 250 other desired species per acre.
- F. Manage for other species using the appropriate silvicultural guide.
- G. Do nothing at this stage. Reexamine in 10 years or at age 40. Boltwood is the only product objective for paper birch that is feasible on these sites. Consider prescription B.
- H. Thin once to B level. Allow to progress to pole stage. For intensive management, consider fertilization 1 to 2 years after thinning.

Figure 14.—Flow chart of silvicultural options in reproduction stands 5 to 10 years old, mean stand diameter of 1.5 inches or less.

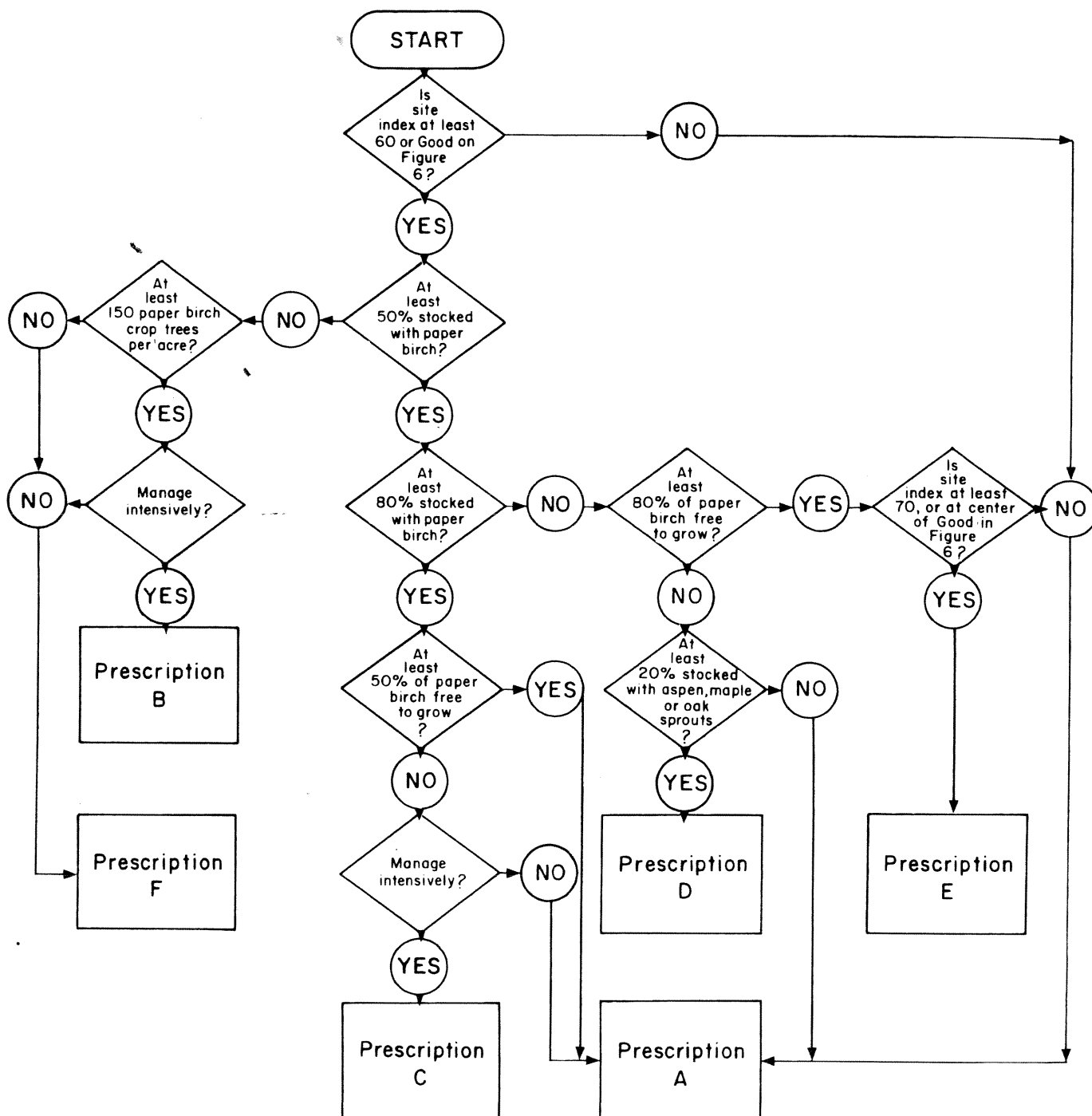


Figure 15.—Flow chart of silvicultural options in sapling stands, mean stand diameter of 1.6 to 4.5 inches.

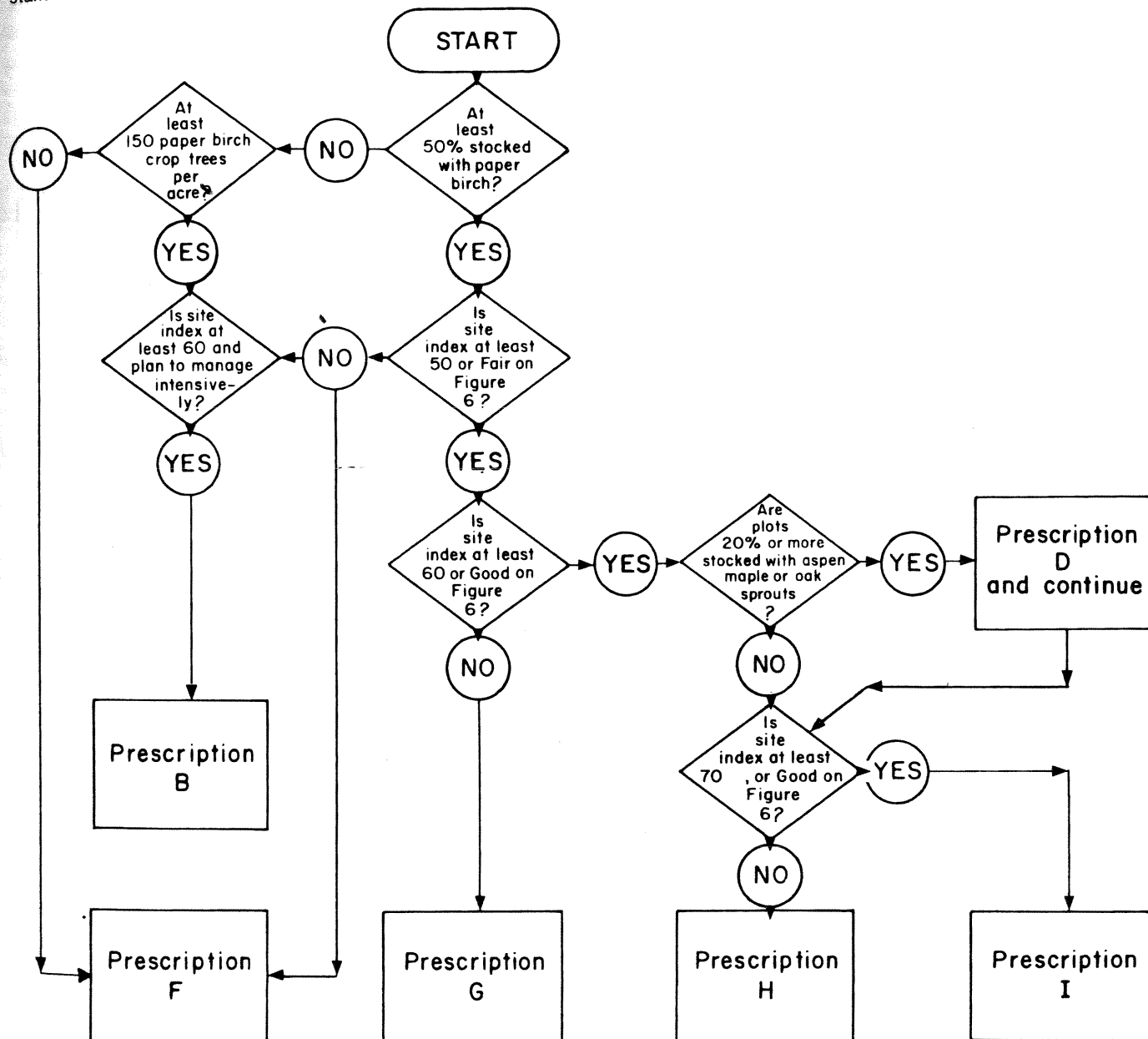


Figure 16.—Flow chart of silvicultural options in pole stands, mean stand diameter of 4.6 to 10.5 inches.

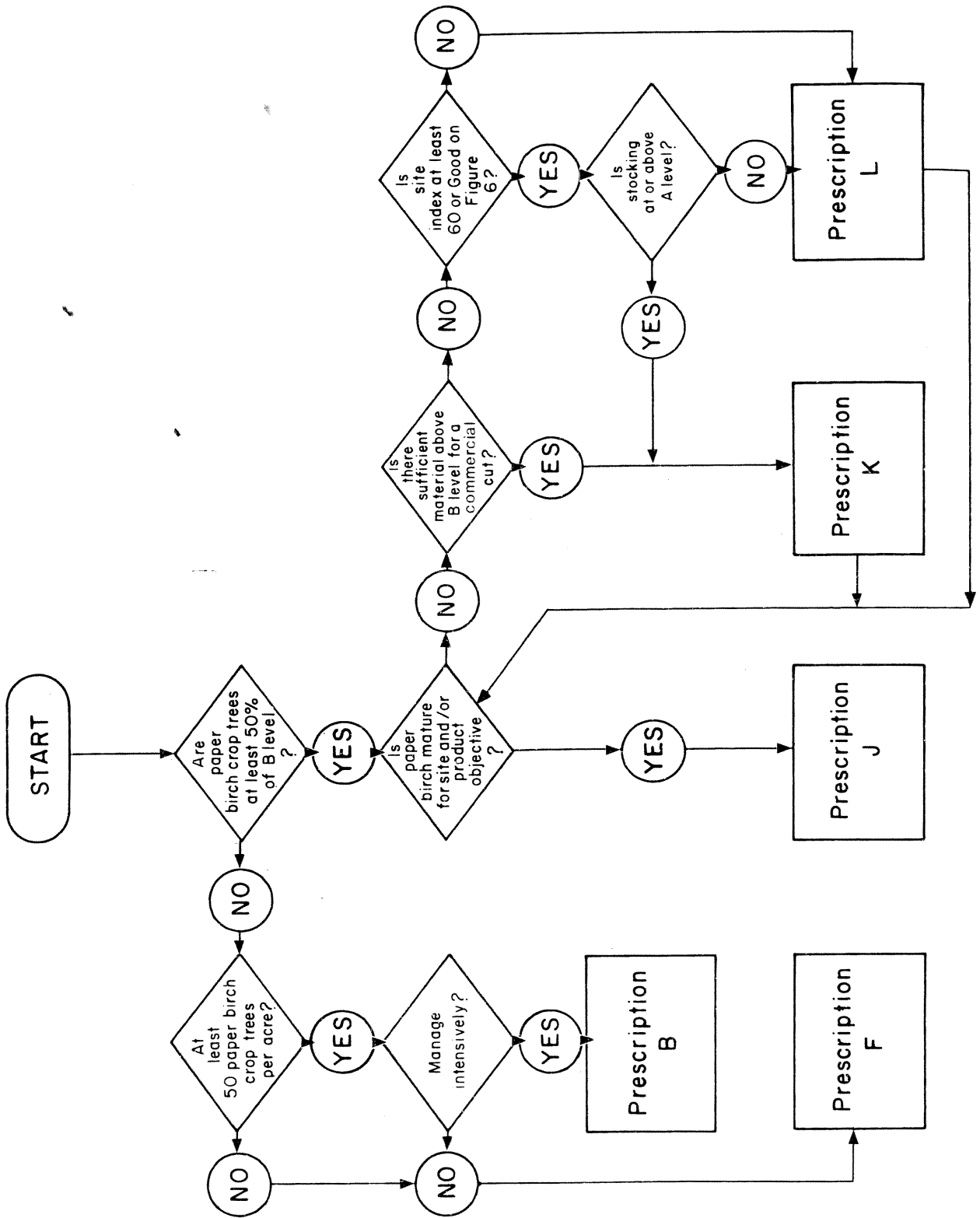
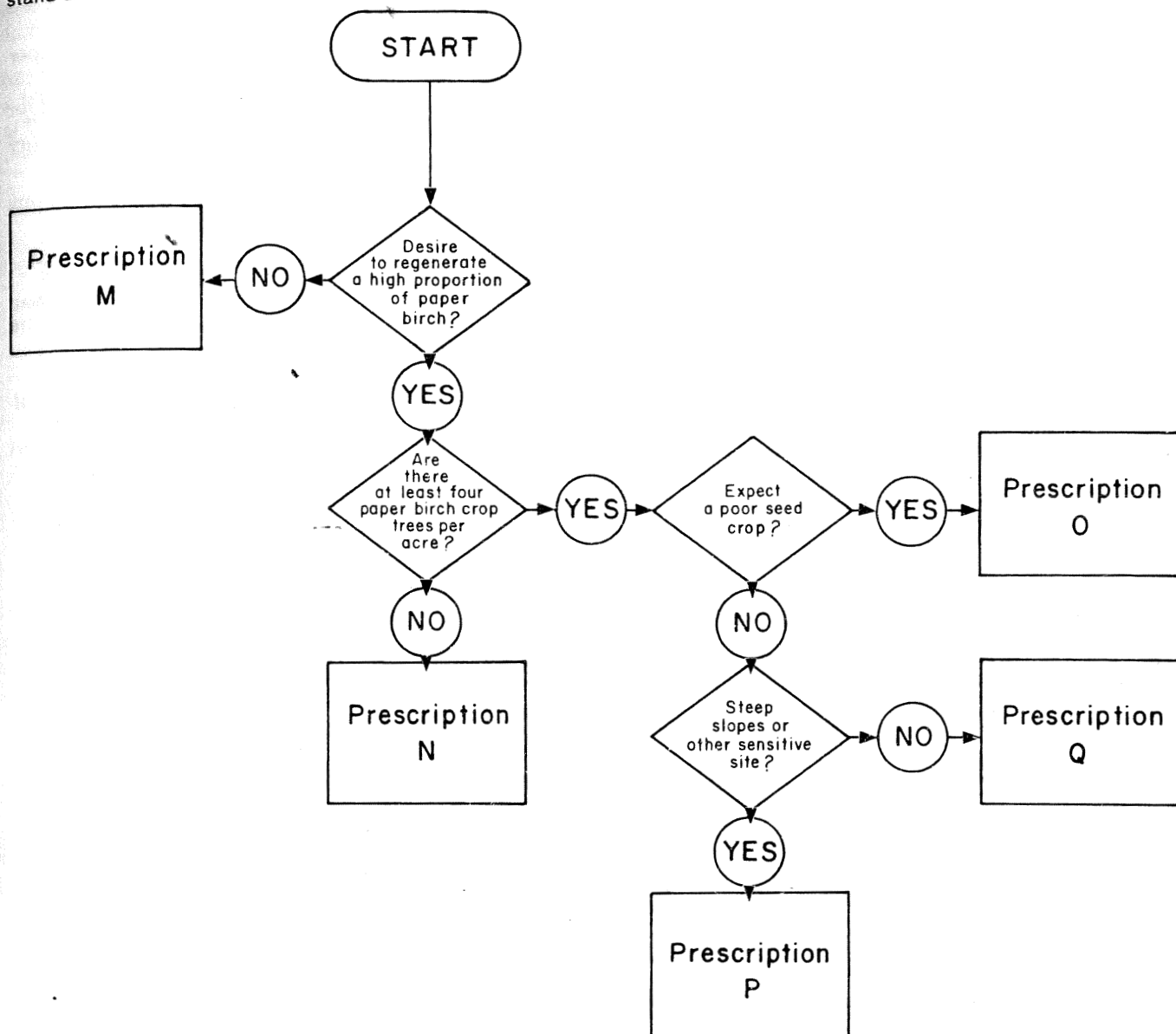


Figure 17.—Flow chart of silvicultural options in sawtimber stands, mean stand diameter of 10.6 inches or greater.



- | | | |
|---|---|--|
| <p>I. Thin to B level now and at intervals of 7 to 10 years until stand reaches pole stage. Subsequent thinnings should produce marketable material. Consider fertilization 1 to 2 years after each thinning.</p> <p>J. Harvest. Go to sawtimber flow chart (Fig. 17).</p> <p>K. Thin to B level, releasing enough paper birch crop trees to make B-level stocking in crop trees alone in about 10 years. Consider fertilization.</p> | <p>L. Do nothing now. Reexamine in about 10 years. Consider prescription G.</p> <p>M. Harvest paper birch and other merchantable products. Manage for other species using the appropriate silvicultural guide.</p> <p>N. Clearcut in a block up to 40 acres in size and direct seed or plant seedlings to obtain desired stocking of paper birch.</p> | <p>O. Postpone harvest until a better seed crop is expected, or clearcut by the progressive strip method. Consider direct seeding.</p> <p>P. Clearcut by the progressive strip or small patch method.</p> <p>Q. Clearcut in a block. If more than 20 acres and cut is in summer, leave 3 to 4 paper birch seed trees per acre.</p> |
|---|---|--|

Literature Cited

Frank, Robert M.; Bjorkbom, John C. **A silvicultural guide for spruce-fir in the Northeast.** Gen. Tech. Rep. NE-6. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1973. 29 p.

Marquis, David A.; Solomon Dale S.; Bjorkbom, John C. **A silvicultural guide for paper birch in the Northeast.** Res. Pap. NE-130. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1969. 47 p.

Lancaster, Kenneth F.; Leak, William B. **A silvicultural guide for white pine in the Northeast.** Gen. Tech. Rep. NE-41. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1978. 13 p.

Leak, William B.; Solomon, Dale S.; Filip, Stanley M. **A silvicultural guide for northern hardwoods in the Northeast.** Res. Pap. NE-143. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1969. 34 p.

Acknowledgments

I thank William Leak and Dale Solomon for their reviews and suggestions, especially in sharing their stand growth data for this revised stocking guide. I also thank Kenneth Lancaster, George LaBonte, and Maxwell McCormack, Jr. for their helpful comments on the manuscript.

Caution

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment as specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary landfill dump, or crush or bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Environmental Protection Agency, consult your local forest pathologist, county agricultural agent, or State Extension specialist to be sure the intended use is still registered.

Appendix I

Measuring Site Index

1. Select five or more dominant paper birch or other species to which curves apply. These trees should be among the tallest trees in the stand, straight, and free from injury and disease.
2. Measure height from two directions at approximately right angles.
3. Bore at breast height and count rings for age. Sugar maple and white ash are easier to count than the birches. If ash is used, be sure it is not of sprout origin.
4. Using height and age data, read site index from appropriate set of curves. If sugar maple, ash, or yellow birch was measured, convert to paper birch site index using Figure 2.
5. Determine the values of five or more trees to obtain average site index for the stand.

Appendix II

Number of trees per acre by diameter class and number of trees tallied for a 10-factor prism.

Number of trees tallied	Diameter class (inches)												
	2	4	6	8	10	12	14	16	18	20	22	24	26
1	458	115	51	29	18	13	9	7	6	5	4	3	3
2	917	229	102	57	37	25	19	14	11	9	8	6	5
3	1375	344	153	86	55	38	28	21	17	14	11	10	8
4	1834	458	204	115	73	51	37	29	23	18	15	13	11
5	2292	573	255	143	92	64	47	36	28	23	19	16	13
6	2750	688	306	172	110	76	56	43	34	27	23	19	16
7	3209	802	357	201	128	89	65	50	40	32	26	23	19
8	3667	917	407	229	147	102	75	57	45	36	30	26	21
9	4125	1031	458	258	165	115	84	64	51	41	34	29	24
10	4584	1146	509	287	183	127	93	71	57	46	38	32	27
11	5042	1260	560	315	202	140	103	78	62	50	42	35	29
12	5501	1375	611	344	220	153	112	86	68	55	45	39	32
13	5959	1490	662	373	238	165	121	93	74	59	49	42	35
14	6417	1604	713	401	257	178	131	100	79	64	53	45	37
15	6875	1719	764	430	275	191	140	107	85	68	57	48	40
16	7333	1834	815	459	293	204	149	114	91	73	60	52	43
17	7792	1948	866	487	312	216	159	121	96	77	64	55	45
18	8250	2063	917	516	330	229	168	128	102	82	68	58	48
19	8707	2177	968	545	348	242	177	136	108	87	72	61	51
20	9167	2292	1019	573	367	255	187	143	113	91	76	64	53

Safford, L.O. **Silvicultural guide for paper birch in the Northeast (revised)**. Res. Pap. NE-535. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1983. 29 p.

This revised guide provides practical information on silvicultural treatments to grow paper birch as a timber crop. It covers treatments for existing stands, the regeneration of new stands, and subsequent culture to maturity. The stocking chart has been revised to reflect results of current growth studies.

ODC 2:614:176.1 (*Betula papyrifera* Marsh.)

Keywords: Silviculture; cutting systems; *Betula papyrifera*

Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories are maintained at:

- Amherst, Massachusetts, in cooperation with the University of Massachusetts.
 - Berea, Kentucky, in cooperation with Berea College.
 - Burlington, Vermont, in cooperation with the University of Vermont.
 - Delaware, Ohio.
 - Durham, New Hampshire, in cooperation with the University of New Hampshire.
 - Hamden, Connecticut, in cooperation with Yale University.
 - Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.
 - Orono, Maine, in cooperation with the University of Maine, Orono.
 - Parsons, West Virginia.
 - Princeton, West Virginia.
 - Syracuse, New York, in cooperation with the State University of New York College of Environmental Sciences and Forestry at Syracuse University, Syracuse.
 - University Park, Pennsylvania, in cooperation with the Pennsylvania State University.
 - Warren, Pennsylvania.
-