THINNING AND PRUNING IN YOUNG BIRCH STANDS

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YELLOW BIRCH and paper birch are similar in that both are light-demanding throughout most of their life and require freedom from competition to produce high-value products. However, the two species differ markedly in other silvical characteristics. Yellow birch seldom constitutes a large proportion of the stand: it grows slowly and is long-lived. In contrast, paper birch sometimes makes up a high proportion of the stand: it has rapid early growth, and tends to be short-lived *(Cooley 1962, Fowells 1965)*. Both birches are responsive to intermediate cuttings and other cultural practices that can increase their yield and value and shorten rotations. Although data for yellow and paper birch are somewhat limited, enough is known to indicate that their response to treatment is comparable to that of other hardwood species.

RELEASE CUTTING

Cleaning and Weeding

Many cutting practices are favorable for germination and establishment of yellow and paper birch. Unfortunately, sprouts and fast-growing undesirable species tend to overtop and crowd out out the more valuable birches *(Eyre and Zillgitt 1953, Hatcher 1966, Jarvis 1956, Jensen 1943, Leak 1961a, Marquis 1967, Wang 1968, Zillgitt and Eyre 1945, Zeedyk and Hough 1958)*. Early release thus becomes necessary if birches are to be an important part of the stand at maturity.

Early release is particularly important for yellow birch, because it often makes up only a small percentage of the reproduction, and its slower height growth causes it to lose dominance at an early stage of development. Paper birch has a greater tendency to retain dominance *(Gilbert 1965, Leak 1961b, Marquis 1965 and 1967)*, but it is frequently overtopped by sprouts and low-value species.

Methods of Release

Release work should be started as soon as the desirable trees show a decline in growth rate, or when other trees begin to overtop them. This occurs for most hardwood species between 10 and 20 years of age *(Downs 1942, Gilbert and Jensen 1958, Stoeckeler and Arbogast 1947)*. The primary objectives in release work are to provide adequate growing space for the potential crop trees and at the same time to keep the investment in time and money as low as possible. Most studies have shown that crop-tree selection will most readily meet these objectives *(Downs 1946, Church 1955, Jemison and Hepting 1949, Jensen 1943, and Stoeckeler and Arbogast 1947)*.

Careful selection of potential crop trees is necessary to assure that they will remain in a favorable crown position and develop good form. Such trees can usually be identified by their crown position, bole condition, and stem origin. Present crown position is the most important criterion. Dominant or codominant trees generally develop and maintain good growth and vigor after release, but intermediate trees are susceptible to stem breakage and mortality and often do not develop into high-quality stems *(Downs 1946, Church 1955, Conover and Ralston 1959, Drinkwater 1960, Stoeckeler and Arbogast 1947)*.

Intensity of Release

Because the degree of release will influence both the growth rate and future quality of the stem, it is often necessary to compromise to achieve the best development in both growth and quality. Initial treatments can often be heavier in smaller and younger stands than in larger and older stands. Current guidelines for the intensity of release are usually based on the amount of growing space to leave between competing trees rather than on a basal area or number of stems per acre.

The crown-space requirements for yellow and paper birch tend to be similar to those for sugar maple.[1] In a study of release treatments in an 11-year-old stand in the Lake States, a spacing of approximately 4 feet between stems, or about one-fifth the total tree height, was recommended for all hardwood species *(Stoeckeler and Arbogast 1947)*. In a 25-year-old stand in Nova Scotia that contained a limited amount of yellow birch, removing competing stems to leave a space of 5 to 6 feet between crowns gave the best results *(Drinkwater 1960)*. Similar crown spacing in stands of comparable age appeared to give the best results in the Northeast *(Church 1955, Downs 1946, Gilbert and Jensen 1958)*.

Time Requirements

The time required for releasing crop trees tends to be high, but will vary with the method and intensity of release. In a study in the Northeast in which a combination of herbicides and cutting tools were used, approximately 12 man-hours were required to release 100 trees per acre in a predominantly yellow and paper birch stand. The time required per acre could be estimated by the formula: man-hours per acre $= 4.06 + 0.088$ times the number of crop trees released *(Blum and Filip 1962)*. In a mixed hardwood stand in the Lake States, the time required to release 180 trees per acre, using cutting tools, was 10.0 man-hours per acre if the trees were released to a radius of 2.5 feet between stems; to release the same number to a radius of 5 feet between stems required 25 man-hours *(Stoeckeler and Arbogast 1947)*.

New tools, particularly herbicides and their applicators, hold promise for reducing the time required; and they have the added advantage of reducing or eliminating sprout growth that often follows cutting of the stems *(Smith 1962)*. Because of the relatively high cost of release, crop trees should be picked carefully, and time should be spent in removing only those trees that are retarding growth of crop trees.

Growth Response

The growth response that can be expected after treatment varies with the amount of release and the condition of the tree at the time of release. The heavier the release, the greater the diameter growth. Diameter growth rate of trees in a Pennsylvania stand that contained yellow birch increased markedly after moderately heavy weeding, but very little after light weeding *(Church 1955)*. Paper and yellow birch crop trees grew faster after heavy thinning than after light thinning in a New Hampshire study *(Marquis 1969)*.

Crown class or size of tree also affects diameter growth. In general, the larger and more dominant trees show the largest absolute growth increase after thinning, although the percentage increase may be greater for smaller trees *(Marquis 1969)*. Suppressed or low-vigor trees often respond poorly to release *(Downs 1946)*.

The effect of release on height growth has not been studied as intensively as the effect on diameter growth; but height growth is known to be influenced by the amount of overhead shade *(Jacobs 1965, Logan 1965)*. Some studies have indicated that heavy release may cause a temporary reduction in annual height growth *(Ostrom and Hough 1944, Stoeckeler and Arbogast 1947)*, but others have found little effect *(Downs 1946, Drinkwater 1960)*.

Although both height and diameter growth rate of birches may be affected by release, the impact on volume yield has not been fully determined for birch stands. Detailed studies of associated species clearly show that volume growth can be effectively shifted to crop trees. However, these studies suggest that follow-up treatments are usually necessary to maintain the early increase in volume growth *(Conover and Ralston 1959)*.

Tree Quality

The management objective for yellow and paper birch is to develop trees that will yield high-value products. The effect of release on stem quality has generally been considered negligible after short-term appraisals *(Drinkwater 1960, Ostrom and Hough 1944, Stoeckeler and Arbogast 1947)*. However, heavy release treatments have been reported to ad-

[1] Unpublished data, U.S.D.A. Forest Serv. North Central Forest Exp. Sta., St. Paul, Minn.

versely affect the grade and value of trees as they approach commercial size, and the time period after the initial release has been extended. Sixteen years after a heavy release in a Wisconsin hardwood stand, clear bole length was 4 feet shorter on released trees than on the unreleased trees *(Conover and Ralston 1959)*.

The merchantable length of birches and other species with indeterminate growth characteristics is often reduced because of the increased forking that is associated with low stand density. Such trees are undesirable in forest stands *(Clausen and Godman 1967, Conover and Ralston 1959)*. Although competition between the crowns tends to correct forks, those in the upper stem persist for long periods and often cause an appreciable loss in merchantable volume. Forks at this position are also susceptible to splitting and complete crown loss, particularly when the crowns are opened up by later thinnings. Adequate densities must be maintained to stimulate early recovery from forking.

The thin bark of birches makes them highly susceptible to winter sunscald. Although this type of injury seldom results in mortality, it often causes volume and grade loss in potentially high-value trees *(Blum and Filip 1963)*. Because sunscald is common in young trees with thin bark, the south and southwest sides of the stem must be protected in releasing birch *(Blum 1963, Godman 1959, Lake States Forest Experiment Station 1940)*.

Liberation Cutting

Shade cast by holdover trees usually benefits yellow and paper birch seedlings during their establishment. However, retention of this shade, usually from cull or low-quality trees, will reduce seedling height growth and development. This shading effect usually extends about 1 foot from the stem of the overstory tree for each inch of its diameter *(Stoeckeler and Arbogast 1947)*. Removal of the overstory—termed liberation cutting—is often necessary to ensure that yellow and paper birch will be components of the final stand.

Complete removal of the overstory after the regeneration is about 2 feet tall results in better growth and stand development than partial removal of the overstory *(Eyre and Zillgitt 1953, Hatcher 1966, Jensen and Wilson 1951, Lake States Forest Experiment Station, 1940)*. Cutting the overstory before the seedlings reach this height may result in heavy seedling mortality because of the sudden exposure. Established yellow and paper birches in a Canadian study showed a 6.4-percent growth response after complete release, compared to only 1.8 percent for untreated trees *(Maclean 1949)*.

Low-value overstory trees can be removed economically by girdling the stem or applying chemicals *(Smith 1962)*. Both methods have the advantage of gradually reducing the shade cover, thus allowing the seedlings to adjust to increasing light intensity and reducing the chance of stem breakage *(Arbogast 1950, Eyre and Zillgitt 1953, Stoeckeler and Arbogast 1947)*. However, stem breakage in seedlings is usually not serious because the stem deformities become corrected before the trees reach sapling size *(Switzenberg et al. 1955)*.

Summary of Release Cutting

Release treatments thus appear to be necessary where the slow-growing yellow birch is an important stand component and where paper birch is either overtopped by more tolerant species or is growing in dense stands. It is generally agreed that moderate release treatments started early and repeated as often as necessary will stimulate and concentrate growth on the most desirable trees. Careful selection of individual trees on the basis of crown class and vigor can be expected to give the greatest success.

Because birch trees are sensitive to sudden exposure, moderate release—leaving trees on the south and southwest sides for protection—should minimize injury to the stem. Although few studies have been carried long enough to fully evaluate the economic benefits of release in terms of volume and grade, there is little doubt that release will be economically justifiable in managing birch stands to produce high-value products with short rotations *(Webster 1960)*.

THINNING

Thinning pole-size birch stands is a complex practice because each cutting involves composition control, quality selection, and differential release. The best results are usually obtained by making a crown or crop-tree thinning around selected trees that have good growth and quality potential. Because paper birch has a relatively short life span, stands where it is a major component should be thinned fairly early. Most paper birch trees are pathologically mature by age 80 on the better sites, and will seldom respond to thinnings after age 60 *(Gilbert and Jensen 1958)*. Yellow birch also benefits from early thinning, but the treatments can be carried out over a longer period because of its longer life span and ability to respond to release at advanced ages.

Thinning of young hardwood stands implies that the composition and growth of the stand will be improved by providing more crown space for desirable species (which are often the least aggressive), and that the quality of the individual tree will be improved by increasing the volume and clearwood production. To achieve these objectives, early thinnings are recommended *(Webster 1960)*. Normally, thinnings should be started before the live-crown ratio drops to 40 percent of the total height *(Gilbert and Jensen 1958)*, and should be repeated at 10- to 15-year intervals to maintain desirable growing conditions.

The diameter-growth response of yellow and paper birch tends to be strongly related to the amount of release and to the size of the tree at the time of thinning. Larger trees grow faster after thinning than smaller trees, at least up to 16 inches in diameter; and the growth rate of trees in each diameter class increases as the intensity of the cut is increased *(Jensen 1943)*.

In a more recent study in the Northeast, similar increases in diameter growth of yellow and paper birch were obtained during the first 5 years after thinning in a 25-year-old mixed-species stand (table 1).[2] The heavy thinnings resulted in a growth increase of 78 percent for yellow birch and 29 percent for paper birch. Perhaps more important than growth rate, the heavy early thinning resulted in a five-fold increase in the number of dominant crop trees and a two-fold increase in codominant crop trees compared to the control treatment *(Marquis 1969)*. Early thinnings that maintain crown position in the stand and stimulate diameter growth can be expected to appreciably increase the volume of less tolerant species in the final crop.

Short-term studies of quality change after thinning generally show little adverse effect on potential grade and value of the stem. However, maintaining heavy cuttings for extended periods tends to reduce potential quality of pole-size yellow birch (table 2).[1] Although the stem-quality trends for yellow birch shown in table 2 are based on a limited number of potential crop trees, they are substantiated by similar results from much larger samples of other hardwood species. Of the hardwoods studied, yellow birch was intermediate in frequency of all grade defects. Less tolerant species, such as basswood and white ash, had fewer defects, while sugar maple, the most tolerant species in the study, had the most defects.

The number of live limbs generally increased as residual stand density decreased, particularly in the second log. And live limbs present in the butt log tended to persist after heavy cuttings. These changes in live branches are a reflection of the deeper and larger crowns that develop in heavily thinned stands. Such crowns permit rapid diameter growth, but quality and net value may suffer because live branches persist and reduce the clear length of bole. Thus heavy thinnings should

Table 1.—*Average annual diameter growth of yellow birch crop trees for 5-year period after thinning*

Treatment	Diameter growth per year	
	Yellow birch	Paper birch
	Inches	*Inches*
Control	0.09	0.14
Crude thinning[1]	.10	.17
Light crop-tree thinning[2]	.11	.17
Heavy crop-tree thinning[3]	.16	.18

[1] All aspen, pin cherry, and striped maple in main canopy cut, and all red maple sprout clumps thinned.

[2] One of the trees competing with each crop tree removed.

[3] All trees competing directly with crop trees removed.

[2] Unpublished report: RESPONSE OF A 25-YEAR-OLD NORTHERN HARDWOOD STAND TO EARLY THINNING. David A. Marquis, USDA Forest Serv. NE. Forest Exp. Sta., Upper Darby, Pa.

probably be avoided until the potential crop trees are pruned to the desired height. After these lower limbs die, the rate of quality improvement can be stimulated by thinning to lower densities.

Although epicormic branches are less of a problem in the birches than in many other species, they are still an important factor in quality development. Epicormic sprouting was most abundant in the untreated stand, probably due to intense competition between crowns of the crowded trees. However, factors other than stand density appear to affect the incidence of epicormic sprouting, especially the condition of the crown and its development after thinning. More study is needed on the tree and stand conditions that favor epicormic sprouting, but present indications are that proper tree selection and early thinning will help to minimize this problem.

Although natural pruning and subsequent healing of the wounds are the primary determinants of stem quality, other factors should also be considered in determining the most desirable residual stocking for yellow birch (table 3).

Forks are a problem in even-aged stands and intolerant species, regardless of stand density. However, heavy thinnings tend to increase the proportion of trees with forks and the incidence of forks higher on the stem. There appears to be little chance of eliminating forks in stands managed at lower densities because of the lack of competition between crowns. As a result, merchantable length may be reduced and tree loss or growth reduction due to breakage may be increased.

Thinning guides for yellow and paper birch are now available that are applicable to a wide range of stand conditions or different methods of management *(Arbogast 1957, Leak et al. 1969, Marquis et al. 1969)*. In even-aged stands common to the Northeast, the minimum recommended stocking varies with stand age and size. For example, recommended minimum stocking for mixed north-

Table 2.—*Number of defects in yellow birch 15 years after thinning to different stand densities. Based on 54 trees originally 5 to 8 inches d.b.h.*

(In number of defects per tree)

Defect type	Log position	Treatment (and residual basal area per acre)				
		Check	Selection cutting[1]			Crop[2]
		93 sq. ft.	90 sq. ft.	75 sq. ft.	60 sq. ft.	60 sq. ft.
Live limbs	First 16′	0.0	0.4	0.0	0.5	0.7
	Second 16′	2.3	3.7	3.8	4.8	6.5
	Total 32′	2.3	4.1	3.8	5.3	7.2
Epicormic branches	First 16′	0.6	0.1	0.3	0.0	0.5
	Second 16′	2.8	0.2	1.3	0.2	1.7
	Total 32′	3.4	0.3	1.6	0.2	2.2
Dead limbs	First 16′	0.3	0.1	0.2	0.4	1.2
	Second 16′	2.6	1.5	0.7	2.0	1.9
	Total 32′	2.9	1.6	0.9	2.4	3.1
Bumps	First 16′	0.7	0.5	0.3	0.9	0.6
	Second 16′	3.2	1.8	1.7	2.9	1.1
	Total 32′	3.9	2.3	2.0	3.8	1.7
All defects	First 16′	1.6	1.1	0.8	1.8	3.0
	Second 16′	10.9	7.2	7.5	9.9	11.2
	Total 32′	12.5	8.3	8.3	11.7	14.2

[1] Treatments recut at end of 10 years to same density.
[2] Crop trees released individually; not recut; present stand density 105 square feet per acre.

ern hardwoods varies from about 55 square feet of basal area per acre for stands 5 inches average diameter up to 95 square feet of basal area per acre for stands 18 inches average diameter *(Leak et al. 1969, Marquis et al. 1969)*. These guides are based on the level of stocking that will produce maximum growth of individual trees without loss of total stand growth — the point of full site occupancy.

We suggest that no more than 40 percent of the basal area be removed at one time. In the pole-size stands typical of the Lake States, where yellow birch is often an important component associated with the more tolerant species, a residual density of 80 to 85 square feet in trees 5 inches and larger is generally recommended and is an acceptable compromise between growth and development of stem quality *(Arbogast 1957, Eyre and Zillgitt 1953)*. However, combining pruning with thinning would normally favor management of yellow and paper birch at lower stand densities to further stimulate diameter growth.

PRUNING

Pruning hardwoods is desirable for producing high-quality sawlogs and veneer bolts on short rotations. However, little pruning is done at present. The chief drawbacks appear to be the long-term investment required, and concern over the incidence of decay and stain that may be associated with pruning wounds. In some species the development of epicormic branches after pruning has negated the removal of existing limbs.

Pruning hardwoods to produce high-grade products usually requires removing only a small number of branches from a few trees per acre *(Skilling 1958, 1959a)*. Much of the early work in hardwood pruning involved removing large numbers of limbs on slow-growing trees in dense stands. These environmental conditions favored the entrance of decay fungi. Detailed studies have shown that only the slow-growing trees develop incipient decay *(Zeedyk and Hough 1958)*, while the fast-growing trees develop little stain or decay *(Skilling 1958, 1959a, 1959b; Zeedyk and Hough 1958)*. Discoloration and decay associated with pruning fast-growing hardwoods seldom extend beyond the annual ring in which the branch was pruned *(Ohman 1968, Skilling 1958)*. The amount of unsound wood associated with artificial pruning is nearly always less than the amount associated with natural pruning because of decay pockets, overgrown bark, and unsound stubs common to natural pruning wounds *(Skilling 1958)*.

Pruning has often been followed by a marked increase in epicormic sprouting and subsequent branch development on the bole *(Eyre and Zillgitt 1953; Conover and Ralston 1959; Skilling 1958, 1959a, 1959b; Stoeckeler and Arbogast 1947; Zeedyk and Hough 1958)*. Though the cause of epicormic sprouting has not been studied intensively, there is evidence that sprouting is related to the vigor

Table 3.—*Form and growth characteristics of yellow birch crop trees 15 years after thinning to different stand densities. Trees were originally 5 to 8 inches d.b.h.*

Residual basal area per acre and thinning treatment	Stem form		Crown size		Diameter growth		
	Trees with forks	Forks at 37 feet or higher	Trees with clear bole length 25 feet or less	Crown diameter/stem diameter ratio	Ave. 15-year increase	Greatest 15-year increase	Trees growing 2 inches or more per decade
	Percent	*Percent*	*Percent*	*Ratio*	*Inches*	*Inches*	*Percent*
93 sq. ft. (check)	78	43	0	21	1.4	2.0	0
90 sq. ft. (selection)[1]	69	54	25	21	1.7	2.4	0
75 sq. ft. (selection)[1]	83	60	—	26	2.1	3.1	17
60 sq. ft. (selection)[1]	88	50	25	23	2.7	4.0	25
60 sq. ft. (crop-tree)[2]	93	50	47	24	2.3	3.2	13

[1] Treatments recut at end of 10 years to same density.

[2] Crop trees released individually; not recut; present stand density 105 square feet per acre.

of the tree at the time of pruning and to the amount of previous release *(Skilling 1959a)*. We feel that pruning should be delayed for a few years after the stand is thinned to allow a buildup in crown vigor, since growth hormones produced in the crown may control the suppression of epicormic sprouting.[1] Few epicormic shoots develop on dominant trees with vigorous crowns *(Cline 1935; Conover and Ralston 1959; Eyre and Zillgitt 1953; Marquis 1967; Stoeckeler and Arbogast 1947; Skilling 1958, 1959a, 1959b)*.

The time required for healing of pruning wounds is strongly correlated with the rate of diameter growth, size of the wound, and length of the residual stub. When good pruning techniques are used, healing time depends almost entirely on the rate of diameter growth. There is a rule-of-thumb for estimating the time required to heal most wounds: a layer of wood about as thick as the width of the wound must be grown before clear wood will form over the pruning scar *(Lohrey 1963, Skilling 1959b, Moss 1937, Stoeckeler and Arbogast 1947, Zeedyk and Hough 1958)*. Thus, fast-growing trees require fewer years than slow-growing trees to produce clear wood over the same size of wound.

Improved tools and equipment for hardwood pruning have yet to be developed. The best method now is by use of hand saws and ladders. Although this method is slower than using power tools, it is the best way to avoid injury to the stem, and it permits cutting the branch close to the trunk *(Moss 1937, Skilling 1959b)*. The time required for pruning varies with both the size and the height of the branch *(Moss 1937)*, but the costs will average about 50 cents per tree in typical second-growth stands under present labor rates.[1]

Pruning yellow and paper birch could become a widespread cultural practice, particularly where stands are thinned heavily to obtain maximum diameter growth. Trees to be pruned should have a fairly rapid rate of diameter growth and should be capable of maintaining a favorable crown position in the stand. Under these conditions, the early investment will be carried for a shorter period, epicormic shoot development should not be a serious problem, and there should be little or no risk of stain or decay entering the stem. The greatest deterrent to pruning the high-value species at present appears to be the lack of efficient pruning tools.

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