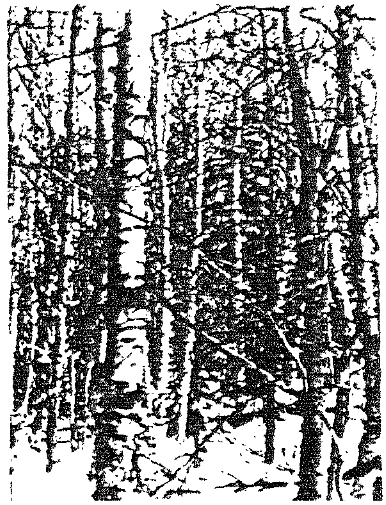

Seedbed-preparation methods for PAPER BIRCH

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

THE SEEDBED REQUIREMENT

PAPER BIRCH is known to regenerate best on disturbed seedbeds where the mineral soil is exposed or is mixed with humus. The advantages of such a seedbed are common knowledge: the roots of the new germinates can penetrate into the mineral soil more easily and quickly than into other seedbeds; mineral soil does not dry out as quickly as humus or litter layers; and surface temperatures are lower on mineral soil (*2, 4*).

This preference for mineral soil seedbeds helps to explain the scarcity of extensive stands of pure paper birch. The wildfires of the past that probably created the kind of seedbeds necessary for paper birch regeneration have become rarities because of modern fire-prevention and control techniques. And modern logging operations seldom provide the required seedbed conditions over extensive areas.

How, then, can favorable seedbeds be provided? And must specially prepared seedbeds be provided to regenerate paper birch? These questions are faced by every forester whose management objectives include the regeneration of this species. To find some answers, the Northeastern Forest Experiment Station began a study in 1958 to learn more about the effect of seedbed preparation on paper birch regeneration. This report presents the results of that study.

THE STUDY AREA

The study area, situated on a low-lying ridge about 200 feet in elevation, is located on the Penobscot Experimental Forest in Maine. The land has a gentle northeasterly aspect. The soil underlying most of the area is the Thorndike stony silt loam, well-drained and shallow to fractured shale bedrock. Some small depressions within the study area collect water and, in some years, remain wet into the summer months.

The forest stand occupying this area originated after a fire about 70 years before the establishment of the study (fig. 1). The species present in order of abundance were as follows:

Red Maple	*Acer rubrum* L.
Paper birch	*Betula papyrifera* Marsh.
American beech	*Fagus grandifolia* Ehrh.
Balsam fir	*Abies balsamea* (L.) Mill.
Red spruce	*Picea rubens* Sarg.
Gray birch	*Betula populifolia* Marsh.
Bigtooth aspen	*Populus grandidentata* Michx.
Sugar maple	*Acer saccharum* Marsh.

In general, the trees were small. None of them exceeded 13 inches d.b.h. and about three-fourths of them were in the 2-to-4-inch class. The stand volume averaged about 8 cords per acre, of which 75 percent was paper birch. The remaining volume was mostly in red maple and aspen, with minor amounts in the other species.

Within this stand, a study area 7 chains square was laid out to include 8 plots surrounded by a ½-chain isolation strip. Each plot was 1.5 by 3.0 chains, or 0.45 acre. The entire study area was then clearcut except for 50 paper birch seed trees evenly distributed over the plots at a density of about 14 trees per acre. The seed trees averaged 7.8 inches d.b.h. and 55.2 feet tall.

The eight plots were treated with four seedbed-preparation methods. Each treatment was applied to two plots. These treatments were: (1) disking after winter logging, (2) burning after winter logging, (3) summer logging with no supplemental treatment, and (4) winter logging with no supplemental treatment (control).

Each plot was sampled by means of 100 randomly located milacre subplots to determine the tree species present, the percent of mineral soil exposed, the percent of stocking, and the degree of deer browsing. In 20 of the subplots on each main plot, one 1/4-milacre was used for estimating the numbers of germinates per acre and the distribution of seedlings by height classes. Two seed traps, each 3 feet square, were placed on each plot to estimate seedfall.

Figure 1.—The forest stand before cutting.

SEEDBED PREPARATION

In March 1958, with snow still on the ground, the isolation strip and all plots except those scheduled for summer logging were cut. The summer-logged plots were cut in June 1958. All the merchantable pulpwood was stump-cut and tractor-yarded with a rubber-tired flat trailer. On all plots, the unmerchantable trees, saplings, and advance reproduction more than 3 feet in height were cut after logging and left as slash. In effect, the only trees left standing were the seed trees and seedlings less than 3 feet tall (fig. 2).

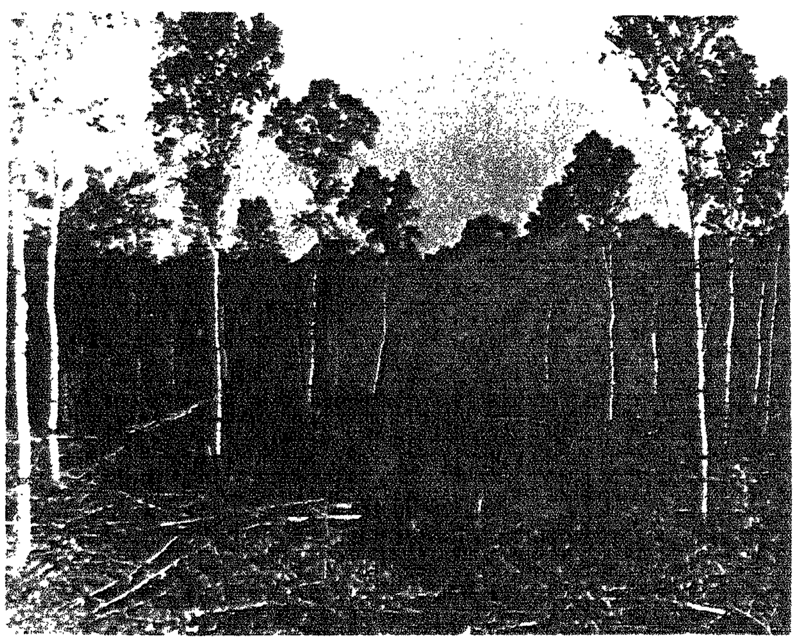

Figure 2.—After clearcutting, the seed treees were essentially the only trees left standing, and slash covered the area.

The disking was done in August 1958 by using an Athens disk harrow weighted with 300 pounds of sand. To facilitate this operation, the stumps were cut to ground level, and the slash was bulldozed off the plots. Even so, repeated passes with the harrow were required for complete scarification of the soil.

The burning treatment also was carried out in August. To confine the fire within prescribed limits, the slash was pulled back from the plot boundaries. A good burn was achieved; most of the smaller slash was completely consumed.

RESULTS

The results in terms of exposed mineral soil, species present, stocking, and height growth are based on data from 800 milacre and 160 ¼-milacre sampling units. These units were first measured in September 1958 and then annually till the final measurement in September 1963.

The data on seedlings of paper birch and the other common pioneer species on the plots—gray birch, pin cherry (*Prunus pensylvanica* L.f.), and bigtooth aspen—are reported separately. Seedlings of all other hardwood species are combined as "other hardwoods"; similarly, all softwoods and all hardwood sprouts are each lumped together.

Data on the seed crops for 1958-60 are based on monthly catches of paper birch seed from August until spring each year.

Exposed Mineral Soil

Disking and burning exposed the greatest amount of mineral soil—74 and 70 percent respectively—and the distribution of mineral soil was relatively even over the plots. All of the 400 sample milacres in these treatments had at least 10 percent of their area in exposed mineral soil; 85 to 90 percent of them had mineral soil exposed on one-half or more of their area.

On the other hand, summer-logging and winter-logging exposed mineral soil on only 6 percent and 5 percent of the respective plot areas. About three-fourths of the milacres in these treatments were not scarified at all or had only a trace of their area exposed; 99 percent of them had less than one-half of their area in mineral soil.

In general, our results are in keeping with results obtained in New Hampshire *(3)* and in the Lake States *(1)*.

Seed Supply

The amount of paper birch seed dispersed over the study area—and its viability—differed considerably among the 3 years of record. The 1958 seedfall was an estimated 1,300,000 seeds per acre, and the average germination was 13 percent. This seed crop produced most of the paper birch regeneration on the plots.

The seedfall in 1959 was about 800,000 seeds per acre and the average germination was 24 percent. In 1960 the figures soared to 16,800,000 seeds per acre and 77 percent average germination. Each of these seed crops, by seeding in the blanks from the preceding years, contributed to the total regeneration.

The seedfall varied among plots and treatments without any discernible pattern except that seedfall was rather consistently less on the two burned plots: the mean was never more than about one-half the means for the other treatments. However, enough seed from the 1958 crop fell on all plots to produce ample regeneration the next year.

Presence of Species

Seedbed-preparation method had a strong influence on the abundance of the species that were present, but had little if any influence on species' presence or absence. As shown in table 1, most species or species groups were represented in all treatments in 1959 and thereafter, but numbers per acre differed considerably.

Differences in abundance of paper birch between the disked plots and the logged-only plots are believed to be mainly a reflec-

Table 1. — *Number of stems per acre, by species, origin, and treatment, September 1958, 1959, and 1963*

(In thousands of stems)

Origin and species	1958				1959				1963			
	Disked	Burned	Summer logged	Winter logged	Disked	Burned	Summer logged	Winter logged	Disked	Burned	Summer logged	Winter logged
Seedlings:												
Paper birch	1	2	1	5	245	50	66	34	50	19	12	8
Gray birch	0	0	0	0	7	2	2	1	5	3	3	1
Pin cherry	0	0	0	0	10	6	7	6	2	2	2	1
Aspen	0	0	0	(1)	19	2	2	(1)	9	2	2	(1)
Other hardwoods	(1)	0	1	5	1	1	1	2	(1)	0	1	1
Softwoods	(1)	0	5	3	1	(1)	5	2	1	0	5	2
Hardwood sprouts	10	7	8	22	2	2	7	6	(1)	(1)	2	4
Total	11	9	15	35	285	63	90	51	67	26	27	17

[1] Fewer than 500 stems per acre.

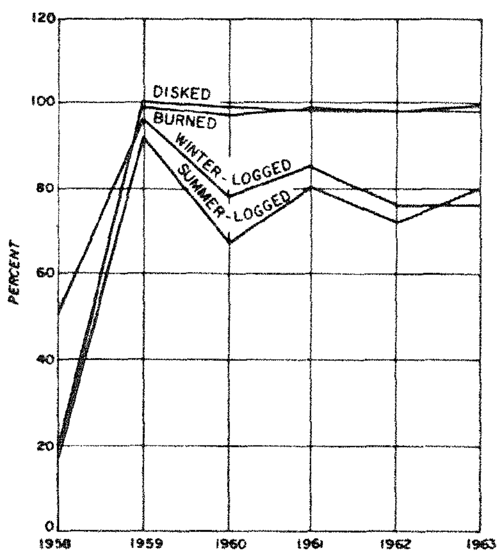

Figure 3.—The percent of milacres containing paper birch seedlings, by treatment and year.

tion of the amount of exposed mineral soil. But mineral soil seedbeds are not enough to guarantee paper birch regeneration. The burned plots, with a high proportion of area in exposed mineral soil, did not do nearly so well.

The reasons for this are not clear. Although the lighter seedfall on the burned plots doubtless was a limiting influence, some other unfavorable factor apparently was involved. Perhaps the smoother, more compact seedbed surfaces were less conducive to seed lodgment, germination, and early seedling survival than the disked surfaces.

The abundance of the other hardwoods and the softwoods was also influenced by treatment. Since these species were generally present as advance growth, their numbers were reduced particularly by the disking and burning treatments.

The method of seedbed preparation apparently had little effect on species' presence, and it is particularly significant that the kind of treatment did not appreciably affect the presence of paper birch. In September 1959, nearly every milacre in every plot had some paper birch present. Although the number of these milacres with birch decreased with time in the summer-logged and winter-logged plots, a minimum of 76 percent of these milacres still bore paper birch seedlings in 1963 (fig. 3).

In addition to tree species, some grasses and shrubs were also present. Together they have had a limiting influence on forest tree regeneration.

Although grasses were found on all plots to some degree, they were far more common on the disked and burned plots. The wet areas appeared to be particularly susceptible to invasion by grasses. Where there is a heavy cover of grass, some paper birch seeds may not even reach the ground, and any germinates that do begin may be smothered. Sweet fern *(Myrica asplenifolia* L.), found principally on the disked and burned areas, produced patches of dense cover that also limited paper birch regeneration.

Stocking

Stocking was estimated on the basis of milacre sampling units. A milacre was considered stocked if it contained a seedling or sprout of a commercial forest tree species. Where more than one stem was present, the tallest seedling or sprout was recorded as the stocking species. Stocked milacres, expressed as percent of the total number of milacres observed, were used to evaluate the effectiveness of the seedbed-preparation methods.

At the end of the 1958 growing season—the first fall after the treatments were completed—the winter-logged control plots were fully stocked and the summer-logged plots were 91-percent stocked. Because only about 2 months had elapsed since the disking and burning were done, the treated plots were less than two-thirds stocked.

Hardwood sprouts stocked many more milacres in the fall of 1958 than did seedlings and were most abundant on the winter-logged areas. In general, red maple and paper birch sprouts were most common. At the same time, seedling stocking on both the winter-logged control plots and the summer-logged plots was mainly softwood species—spruce, fir, hemlock, and white pine. Much of this was advance reproduction. On the disked and burned plots, most of the seedling stocking was hardwoods—roughly one-half pioneer species and one-half other hardwoods. Here ad-

Table 2.—*Percent of milacres stocked, by species, origin, and treatment, September 1958, 1959, and 1963*

Origin and species	1958				1959				1963			
	Disked	Burned	Summer logged	Winter logged	Disked	Burned	Summer logged	Winter logged	Disked	Burned	Winter logged	Summer logged
Seedlings:												
Paper birch	7	5	0	2	36	17	7	20	36	34	12	15
Gray birch	0	1	0	0	7	10	0	3	5	4	4	2
Pin cherry	0	0	0	0	36	41	17	10	1	6	2	2
Aspen	0	0	0	0	4	20	2	1	47	46	11	11
Other hardwoods	7	4	9	2	1	0	3	12	1	0	3	5
Softwoods	9	2	41	22	2	0	35	19	2	1	40	29
Hardwood sprouts	40	52	41	74	14	12	36	35	7	8	27	36
Not stocked	37	36	9	0	0	0	0	0	1	1	1	0
Total	100	100	100	100	100	100	100	100	100	100	100	100

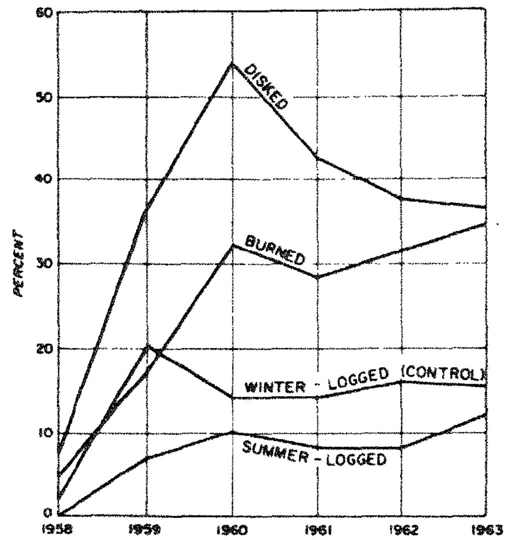

Figure 4.—The percent of milacres stocked with paper birch seedlings, by treatment and year.

vance growth was less common because much of what had been present had been destroyed by these seedbed treatments.

In April 1959 the hardwood sprouts, except paper birch and gray birch, were cut back and the stubs were treated with 2,4,5-T, thus the sprout stocking was reduced considerably. With each year after 1959, the sprout stocking continued slowly to decrease.

By the fall of 1963, paper birch seedlings stocked two to three times as many milacres on the disked plots and burned plots as on the summer-logged plots and winter-logged control plots. These differences, however, were not statistically significant at the 5-percent level. Aspen had responded similarly to the treatments, and stocked more milacres on the disked and burned plots than on the other plots; but here the differences were significant. Hardwood sprouts, on the other hand, stocked significantly fewer milacres in 1963 on the disked and burned plots than on the other plots.

The percent of stocking by species and treatments for 1958, 1959, and 1963 is shown in table 2, and the stocking to paper birch seedlings is shown graphically in figure 4.

Height

Among the seedlings tallied as stocking stems, those of aspen generally made the best height growth in all treatments. Their average heights ranged from 3.0 to 5.8 feet in September 1963. The closest seedling competitors were the advance hardwood and softwood reproduction. On the basis of stocking stems, paper birch, gray birch, and pin cherry were the smallest species, and there was little difference among them (table 3). Differences among the 1963 mean heights of stocking stems shown by species and treatments in table 3 were not statistically significant.

When all seedling stems were considered, paper birch seedlings tended to run smaller than those of all the other species, as shown by the distribution of size classes in table 4.

Total height appears to have been adversely affected by a number of factors. The more obvious ones were browsing by deer and, for the birches, attacks by the birch leaf miner *(Fenusa pusilla)* (Lep) *(=pumila* Klug).

Deer browsing was common and ever-present throughout the study area. None of the hardwood species escaped damage, and certainly paper birch bore its share. Attacks by the birch leaf miner were an annual occurrence. The infestations appeared to be more

Table 3. — ***Average height of stocking stems by species and treatments, September 1963***

Origin and species	Average height			
	Disked	Burned	Summer logged	Winter logged
	Feet	*Feet*	*Feet*	*Feet*
Seedlings:				
Paper birch	2.5	2.8	2.6	2.9
Gray birch	2.6	2.6	2.2	3.2
Pin cherry	2.5	3.2	2.7	2.6
Aspen	3.0	3.6	5.8	4.8
Other hardwoods	3.7	—	3.3	6.0
Softwoods	3.5	3.2	4.4	4.0
Hardwood sprouts	4.5	4.9	6.6	6.8

Table 4. —*Distribution of species by height classes, September 1963*

Origin and species	Height class		
	Under 1 foot	1 to 3 feet	Over 3 feet
	Percent	*Percent*	*Percent*
Seedlings:			
Paper birch	33	67	0
Gray birch	37	57	6
Pin cherry	19	81	0
Aspen	13	77	10
Other hardwoods	29	47	24
Softwoods	28	61	11
Hardwood sprouts	2	39	59

severe on gray birch, but most of the paper birch was also infested. Mice and hares also caused some damage, but their combined effect on either seedling or sprout height was relatively unimportant.

DISCUSSION

The results of this study suggest that abundant paper birch regeneration can be obtained if mineral soil is exposed on a large part of the regeneration area. However, the physical difficulties and the expense of disking and burning to expose mineral soil are such that alternative methods for obtaining the desired stocking of paper birch should be considered.

Both winter-logging and summer-logging without further treatment to expose mineral soil seem to provide conditions for obtaining adequate regeneration, provided it can be maintained in the new stand. In this study, paper birch seedlings were found on about three-fourths of the sample milacres on these treatments. The numbers of seedlings ranged from 8 to 12 thousand per acre —a sizeable resource that should not be overlooked.

But how these young stands will develop can only be guessed at. Is this seedling density at the end of six growing seasons sufficient to produce a commercial timber crop in the future? Are cultural treatments needed to bring enough seedlings through to maturity? What will be the effect on future tree quality? Clearly, investigation of stocking density and early silvicultural treatments might well be worthwhile, not only to help evaluate the need for seedbed preparation, but also to provide management guidelines for the development of more productive paper birch stands.

From our present knowledge, it seems safe to say that if a forest manager has as his objective the development of pure or nearly pure stands of paper birch, his chances of success would be enhanced considerably by making a special effort to expose the mineral soil. On the other hand, if his objective is to regenerate a new stand containing a fair proportion of paper birch in mixture with trees from the advance growth of other species, then clear-cutting alone might be satisfactory. In either case, an adequate supply of viable seed must be at hand, either from reserved seed trees, as in this study, or from bordering stands for strip and patch cuttings.

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