Regenerating Paper Birch in the Lake States with the Shelterwood Method[1]

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ABSTRACT. The two-cut uniform shelterwood method provides abundant seed and shade needed to regenerate paper birch on droughty sites. The key to success is site preparation by cross-discing within 2 years after seed dispersal to (a) incorporate organic matter, particularly brown cubical woody rot, into the mineral soil, (b) to control competing vegetation, and (c) to drill seed into the seed bed. Drilled seed produces seedlings that grow 3 to 4 times faster than seedlings from seed dispersed after site preparation. Because a uniform shelterwood intercepts some precipitation, narrow shaded clearcut strips or strip shelterwoods may be even better for regenerating paper birch.

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Paper birch is a familiar tree of the North American boreal forest. Its natural range spans the breadth of the continent from the arctic tree line south to the cooler reaches of the temperate forest. Paper birch is a pioneer and over most of its range it readily colonizes burns, landslides, mine spoils, and other disturbed land. Nevertheless, toward the warmer and drier extremities of its range in mid-North America, cultural efforts to regenerate the species are apt to fail, and satisfactory regeneration prescriptions are needed.

In this article, we present the findings of an experiment of the shelterwood method to regenerate paper birch (Perala 1987) that may fill that need.

SILVICAL HIGHLIGHTS

We distilled the important regeneration characteristics of paper birch from the comprehensive reviews by Safford (1983), Safford and Jacobs (1983), and Perala (1987).

Paper birch readily reproduces from stump sprouts, but reproduction by seed gives birch its pioneering reputation. Paper birch begins producing seed when 10 to 15 years old. Both quantity and quality of seed depend on warm springs and abundant flowering. The seed ripens in late summer and disperses mostly within 3 months. Silviculturally practical seeding distance is less than 100 yards although some seed may travel many times farther, especially when wind-driven over crusted snow. Paper birch seed retains limited viability for at least 2 years in the forest floor.

The seed coat contains a germination inhibitor that can be neutralized only by stratification or by light. Seeds germinate best at temperatures alternating between 68°F and 86°F, and seedlings grow best on moist disturbed seed beds of mixed mineral soil and organic matter. Undisturbed litter is a poor seed bed because it retains little moisture, has an extreme thermal range, and resists penetration by the germinant radicle. Prepared seed beds steadily deteriorate and lose their receptiveness to new seedlings within a few years. For that reason, seedlings established earliest dominate most seedling populations. Seedlings typically grow only 2 to 5 in. tall the first year (some 8 to 17 in.) and are easily suppressed by competing vegetation.

Like many species considered shade intolerant as adults, paper birch seedlings prosper in half sun and can endure as much as 90% shade for a few years. They prefer air and soil temperatures of 64°F to 72°F and cannot endure drought. Roots proliferate in the upper mineral soil, and rootlets abound in decayed leaves and wood. Although mycorrhizal relationships are unclear, studies of the Eurasian white birches suggest varied and complex symbioses will be found for paper birch also. Growth is best on well-drained fertile sites especially rich in phosphorus and nitrogen.

THE SHELTERWOOD METHOD

The clearcut method, used so successfully to regenerate paper birch in New England, Alaska, and adjacent Canada, has failed miserably in the upper Great Lakes region. The blame is laid on the aggressive root suckering habits of the ever-present aspens and on frequent summer drought (Safford and Jacobs 1983). The growing season water balance (Geraghty et al. 1973) is much less favorable in the continental climate of mid-North America than it is farther east and north.

Narrow progressive clearcut strips, small (patch) clearcuts, and shelterwoods are thought to ameliorate the adverse conditions that prevent paper birch regeneration on droughty sites (Safford and Jacobs 1983). The shelterwood method can provide nearly any condition needed for tree regeneration and produces abundant, uniformly distributed seed (Daniel et al. 1979). Compared to clearcuts, shelterwoods reduce solar radiation beneath the canopy, thereby lowering soil and air temperatures and reducing seedling evapotranspiration. Seedlings usually benefit from shelterwoods on hot, dry sites but seldom on cold, wet sites. Because the shelterwood environment is extremely complex, both beneficial and detrimental effects operate simultaneously with the net result of increased seedling survival but reduced growth (Childs 1985, Mahrt 1985).

The shelterwood method is used to regenerate many eastern North American hardwoods and conifers (Hannah 1988). Paper birch is frequently found in the regeneration (Tubbs and Reid 1984) although they are inhibited by the overstory (Kelty 1987). In the Lake States, regenerating paper birch with the method has recently gained popularity. The Ottawa, Nicolet, Chequamegon, and Chippewa national forests and the Wisconsin DNR have experienced the most success. Except for browsing by deer, failures were difficult to diagnose. Seedbed quality, canopy density, timing and amount of seed dispersal, and all the complexity of the shelterwood environment could not be evaluated because they were so poorly understood. We needed to better identify the factors critical to paper birch seedling establishment and growth.

A SHELTERWOOD STUDY

Methods

In summer 1979 a two-cut uniform shelterwood study was begun in a 60-year-old paper birch stand on a Cloquet sandy loam at the Cloquet Forestry Center of the University of Minnesota, College of Forestry, in north

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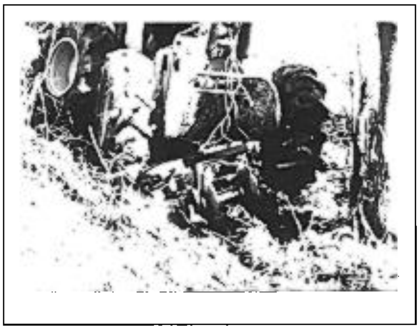
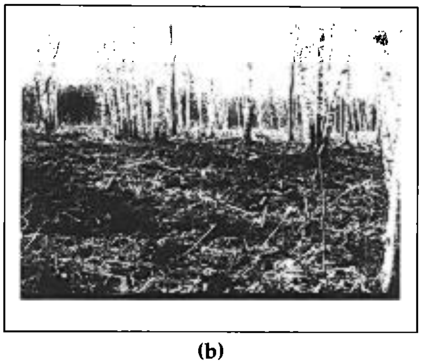
central Minnesota Total stand basal area was 83 ft²/ac, and site index for paper birch (Lundgren and Dolid 1970) was 54 ft at age 50. Four 2.5-ac blocks were partially logged either full tree or tree length. Each block was quartered into 0.6-ac treatment plots having residual densities ranging from 8% to 64% crown cover and 8 to 87 ft²/ac basal area. Late the following summer, two plots in each block were sprayed beneath the canopy with 2 qt/ac of glyphosate herbicide (Roundup®) to control competing vegetation, mostly aspen suckers and herbs. Glyphosate was chosen because it has minimal soil activity and would not interfere with the eventual crop of birch seedlings. Seven weeks later (last week in October 1980) the entire shelterwood was cross-disced (Fig. 1). Ten 5-ft² permanent regeneration plots were installed in each treatment plot to sample seedbed quality and to track revegetation by birch and other plants. Twelve 10-ft² seed traps were installed in the shelterwood, and 10 were installed in the nearest uncut paper birch stand 400 ft west of the study area. The shelterwood was removed one block a year, beginning in the winter 3 years after site preparation.

Results and Discussion

Growing season climate. May to August rainfall ranged from 11.5 to 15.5 in. during the 5-year study, compared to the 30-year mean of 15.0 in. At least 1 month in each of the first 4 years had a drought (consecutive days with less than 0.04 in. rain) exceeding 13 days.



(a)



(b)

Fig. 1. A fire disc pulled by a rubber-tired skidder (a) was used to prepare seedbeds beneath a paper birch shelterwood (b).

July mean temperatures ranged from 66° to 70°F.

Seed production. Opening the stand and injuring the roots by discing caused much crown dieback and killed a few trees. Nevertheless, paper birch seed production was the same per unit basal area in both the shelterwood and the uncut birch stand. Virtually no seed was produced during the year of site preparation nor 2 years later in 1982 (Table 1). A near bumper crop having 40% germination was dispersed in the shelterwood in 1981, and average crops in 1983 and 1984.

Seedlings. Seedlings were more abundant but tended to grow slower on the plots sprayed with glyphosate (Table 1). Despite the seed crop failure in 1980, we found 18 paper birch seedlings per milacre overall in autumn 1981 occurring on 77% of the regeneration plots. They maintained the fastest growth throughout the study. In autumn 1985 they still occupied 49% of the regeneration plots and averaged 34 in. tall (Table 1).

The 1981 seed crop, and to a lesser extent the 1983 and 1984 crops, did produce additional seedlings, but their growth and survival were inferior. In autumn 1982, 95% of the regeneration plots were stocked. Total seedling density was 222/milacre, of which 14/milacre were 2 year olds with 63% stocking, and the rest were 1 year olds (Table 1). By 1985, total seedling density had declined to 22/milacre, but total stocking was still 68%.

Stored seed is important. The evidence is overwhelming that the seedlings in 1981 could have originated only from pre-1980 seed crops stored in the forest floor. In 1980, no seed was collected in the uncut stand; the nearest other possible source of seed over 110 yds away. All the seed in the shelterwood was collected from one trap, yet seedlings in 1981 were well distributed. Germination of the 1980 seed was only 12%, giving on average a little more than one viable seed/milacre to produce 18 seedlings when hundreds of seeds are necessary (Perala 1987). We carefully aged the seedlings by noting bud scale scars and secondary branching. Only a few appeared to survive site preparation

We have no pretreatment seed crop records nor forest floor samples to confirm the stored seed theory. Instead we demonstrated it indirectly In the greenhouse during the summers of 1982 and 1983 (1 and 2 years after the big 1981 seed crop), we cultured fresh forest floor samples taken adjacent to the seed traps in the uncut stand. We forced 25 paper birch germinants per sample square foot in 1982 and 36/ft² in 1983. Greater seedling yield the second year reflects sampling error and improved culture techniques, not the additional seed input in 1982 (1 seed/ft²). Clearly, paper birch seed can retain significant viability for at least 2 years under some conditions.

Annual growth of seedlings derived from seed that fell after discing averaged only 2 in. compared to 8 in. for seedlings from stored seed. The latter seedlings were superior probably because discing lightly covered some seed and protected them from microenvironmental extremes. In contrast, seed that fell on the disced surface endured hotter and drier conditions. Rapid seedling growth is important to seedling survival by improving competitive advantage and by increasing tolerance to browsing by deer.

The right seedbed. Multiple regression analyses (Perala 1987) revealed several seedbed qualities were important to birch seedlings. Mineral soil surfaces were absolutely necessary for seed germination (no seedlings were found on litter), but seedlings grew best if CWD (coarse woody debris, material greater than 1-in. diameter) was incorporated into the seedbed (Fig. 2). CWD, especially brown cubical rot, stores water efficiently, is rich in phosphorus and in biologically fixed nitrogen, and is a source of mycorrhizal inoculum (Larsen et al. 1979, 1980; Harmon et al. 1986). However,

Table 1. Yearly paper birch seed dispersal, seedling density, and dominant seedling height for disced and disced + glyphosate treated seedbeds.[a]

Year	Total seed	Density		Dominant height	
		Disc	Disc + gly.	Disc	Disc + gly
	.... per milacre	....	....	.... in.	....
1980	12	—[b]	—	—	—
1981	24034	16	20	—	—
1982	16	194	251	12	9
1983	2278	63	69	16	16
1984	1874	36	46	34	26
1985	—	19	24	39	29

[a] Coefficient of variation averaged 33%, 23%, and 38% for seed, seedling density, and height, respectively. Differences in seedling density by treatment were significant ($P < 0.05$); differences in seedling height were not.
[b] No sample.

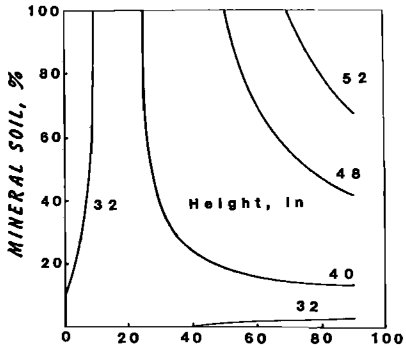


Fig. 2. Dominant 5-year-old paper birch were tallest on seedbeds containing 90% coarse woody debris in a matrix of 100% mineral soil (completely tilled).

only the seedlings arising from seed drilled by discing were able to use CWD to advantage (Fig. 2).

The best seedbeds for both seedling recruitment and growth were shaded yet not overtopped by the canopy. When the canopy intercepts precipitation as well as sunlight, seedlings suffer more from water stress. Therefore, seedlings should prosper best in narrow, shaded clearcut strips that receive full precipitation (*e.g.*, Safford and Jacobs 1983). The net effect on paper birch seedlings is most apparent at the extremes of canopy density (Table 2).

Competing vegetation. Glyphosate controlled only plants that sprouted from rootstocks. Woody competitors (mainly quaking aspen, beaked hazel, and bush honeysuckle) were set back for 5 years, but herbaceous plants (mostly large-leaved aster and bedstraw) for only 1 year. Yet that was sufficient to increase birch seedling density by two-thirds, although growth was not improved (Table 1). Because stocking was sufficient in either case, the added expense of chemical treatment was not justified but might be necessary on richer sites. By itself, discing still provided 27% control of herbs after 2 years, but shrubs were 76% more dominant than on undisturbed soil missed during discing.

Table 2. Paper birch seedling density and dominant height by shelterwood crown cover, 1982.

Crown cover (%)	Seedling density (no./milacre)	Height (in.)
8–15	262	18
16–25	246	10
26–35	207	10
36–45	237	12
46–64	142	3

Removal cut. Logging injury, shock from increased insolation, and dieback reduced average seedling height by nearly one-fourth, but seedling density was not significantly affected. By 1987 after the shelterwood in the last block was removed, all blocks were obviously still well stocked with paper birch seedlings, some of them seedling sprouts. It may be prudent to remove the shelterwood when the seedlings are 1 or 2 years old but only if they are not in danger of smothering by competing vegetation.

RECOMMENDATIONS

A two-cut uniform shelterwood having 20 to 40% crown cover can be used to regenerate paper birch. But any system using narrow shaded clearcut strips or shelterwood strips disced within 2 years ***after*** a good seed crop may be as good or even better. The object of discing is three-fold: (1) incorporate organic matter, CWD in particular, into mineral soil, (2) control competing vegetation, and (3) drill some of the birch seed in the forest floor to optimum depth (1/8 to 1/4 in.) for germination and seedling establishment. Skill in site preparation is critical because too much effort will bury seed too deeply but too little will not mix organic matter with mineral soil nor control competing vegetation. Two passes with a disc at right angles seems about right although research is needed to determine optimum disc size, spacing, and arrangement. Other scarifiers may be effective if they can accomplish the objectives stated above, but we have no experience to support further recommendation. If slash would hinder scarification, full tree logging or scarification in advance of logging may be needed. □

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