# Early Dominance of Pioneer Hardwood After Clearcutting and Removal of Advanced Regeneration

**David M. Smith** *and* **P. Mark S. Ashton,** *Yale University School of Forestry and Environmental Studies, New Haven, CT 06511.*

**ABSTRACT.** *Clearcut openings were created in mixed stands of southern New England hardwoods, hemlock, and white pines to observe the development of new stands in which all species started simultaneously. All pre-existing woody plants, except beech root-suckers and very small seedlings of red oak and hemlock, were eliminated. Natural seedfall was augmented by direct seeding of some species. The main result, after 2 decades, was replacement of the predominant hardwood species of the old stand by black, paper, and yellow birch. Pin cherry and gray birch were initially prominent, especially near the centers of openings, but had died or become moribund. Hemlocks and white pines from new seed persisted in the bottom strata. Except for the birches and black cherry, the hardwood species of the previous stand showed little or no capacity to develop from seed that germinated after clearcutting and removal of advanced growth. North. J. Appl. For. 10(1):14–19.*

The purpose of this study was to determine what species would dominate microenvironmentally different parts of forest openings if many different species started development during the same year. A second purpose was to study the interaction of the different species as the new stands developed.

Earlier studies (Haig 1936, Smith 1951, Hutnik 1952, Marquis 1966, 1973) had suggested the possibility that each species had one or more kinds of microenvironment in which it not only could become established but might also grow faster than its common associates. It has also been shown that, after establishment, differing rates of height growth among species of even-aged mixtures causes them to differentiate into different strata (Oliver 1978, Kelty 1986).

## Procedures

The observations were made in cleared openings at the Great Mountain Forest (GMF) in northwestern Connecticut and the Yale-Toumey Forest (YTF) in southwestern New Hampshire. The pre-existing stands were of mixed species (Table 1) typical of the northern edge of the Appalachian Forest. The openings were all made slightly wider than the adjacent trees were tall in order to allow long durations of exposure to direct sunlight in the northern parts of the openings.

Virtually all advanced growth and sprout regeneration was eliminated from the sites before the new trees germinated. The only exceptions were 1-yr-old red oaks, small seedlings of hemlock, and root-suckers of beech. The small advanced regeneration of red oaks and hemlocks were left because it was already known that these species regenerate poorly in the open (Korstian 1927, Lutz 1928, Olson 1954). It was not then known that this was also true of most hardwood species, as shown later by Marquis (1973). Otherwise the treatment simulated the effects of true clearcutting with site preparation to eliminate pre-existing woody vegetation.

Natural seed dispersal was relied on for most of the new regeneration. However, seeds of white pine, black birch, and paper birch were also broadcast over the openings. Additional species artificially spot-seeded at GMF (but not YTF) were gray birch, yellow birch, sugar maple, red maple, red spruce, red pine, and pitch pine.

**Table 1. Heights and species composition of pre-existing stands, in percentages of basal area, in trees more than 1 in. dbh ranked in decreasing order of overall average dbh.**

| Species | Great Mountain Forest | | | Toumey Forest |
|---|---|---|---|---|
| | Outwash | Thin till | Swale till | Thick till |
| | % of total basal area | | | |
| White pine | — | — | — | 39 |
| Red oak | — | 38 | 7 | 1 |
| Hemlock | 70 | 17 | 11 | 56 |
| Black cherry | — | 11 | 5 | — |
| Red maple | 13 | 20 | 32 | 2 |
| Yellow birch | 10 | 1 | 1 | — |
| Black birch | 5 | — | — | — |
| White ash | — | — | 6 | 1 |
| Sugar maple | 1 | — | 26 | 1 |
| Beech | 1 | 13 | 12 | — |
| Total | 100 | 100 | 100 | 100 |
| Stand ht, ft | 65 | 70 | 80 | 95 |

The YTF site was at 600 ft elevation on a Skerry fine sandy loam, a soil with a fragipan at approximately 20 in. and derived from deep glacial till (USDA Soil Conserv. Serv. 1989). The pre-existing stand (Table 1) had developed on abandoned agricultural land about 1860; some hardwoods had been removed from it about 1935. A circular opening 150 ft in diameter was cut, and virtually all pre-existing woody vegetation was scraped to the side with a small tractor-mounted root-rake during the autumn of 1966. In this case there was very little such vegetation because of the dense shade and allelopathic effect of the hemlock (Ward and McCormick 1982). Substantial areas of mineral soil were exposed. The YTF site was not fenced because deer browsing was not a major factor in the locality. The new seedlings started in 1967 at YTF.

The second and larger experiment was started a year later at GMF. Clearcut strips were substituted for circles because they provided the desired spectrum of microclimatic conditions over much more area and did not have diurnal patterns of shading that were as complex.

Long open strips, 80 ft wide, were created in 1967 at the climatically similar GMF on (a) glacial outwash, (b) thin till, and (c) thicker swale till. Average depth to bedrock was 1.5 ft in the thin till and 3 ft in the thicker till. The surface of the thin till was level and that of the thicker till concave upward. The two till sites were at 1300 ft elevation on extremely rocky fine sandy loam soils of the Hollis series derived from gneiss and schist (USDA Soil Conserv. Serv. 1970).

The outwash site was at 1060 ft on nearly level Sudbury gravelly sandy loam derived from stratified sands and gravels; the water table was close to the surface in spring but much below it later. Each strip was oriented along an east-west axis (true bearing) with a straight southern boundary. The strips were made long enough that no shadows from east or west fell on observation areas except very early and very late in the day.

The pre-existing stands (Table 1) were ones that had developed naturally after very heavy cuttings about 1885; many of the hardwoods were of sprout origin. The cutting was done in the autumn of 1967, and the parts of the strips planned for observations were fenced to exclude the large deer population of the locality. In order to minimize soil disturbance, unwanted advanced growth was killed by basal spraying with herbicides.

Sprout regeneration at the YTF and GMF sites was broken from stumps whenever it appeared; this soon eliminated all sprouts except beech root-suckers. No effort was made to eliminate established herbaceous plants, including those with perennial roots.

Observations consisted of periodic measurements of height of individual plants at various distances north of the stems of the trees at the southern edges of the openings. Measurements made at the end of the second (Figures 1 and 2) and eighteenth (Figure 3) growing seasons were of the tallest plants of each of the comparatively abundant species. The heights for the GMF sites were averages of the 5 tallest seedlings in each 10-ft zone. Those for the YTF site were of the tallest individuals at 6.6-ft intervals for the end of the second growing season only. In the early stages, yellow and black birch could not be reliably differentiated, and both are shown together as black birch.

After 1974, measurements were periodically made of the

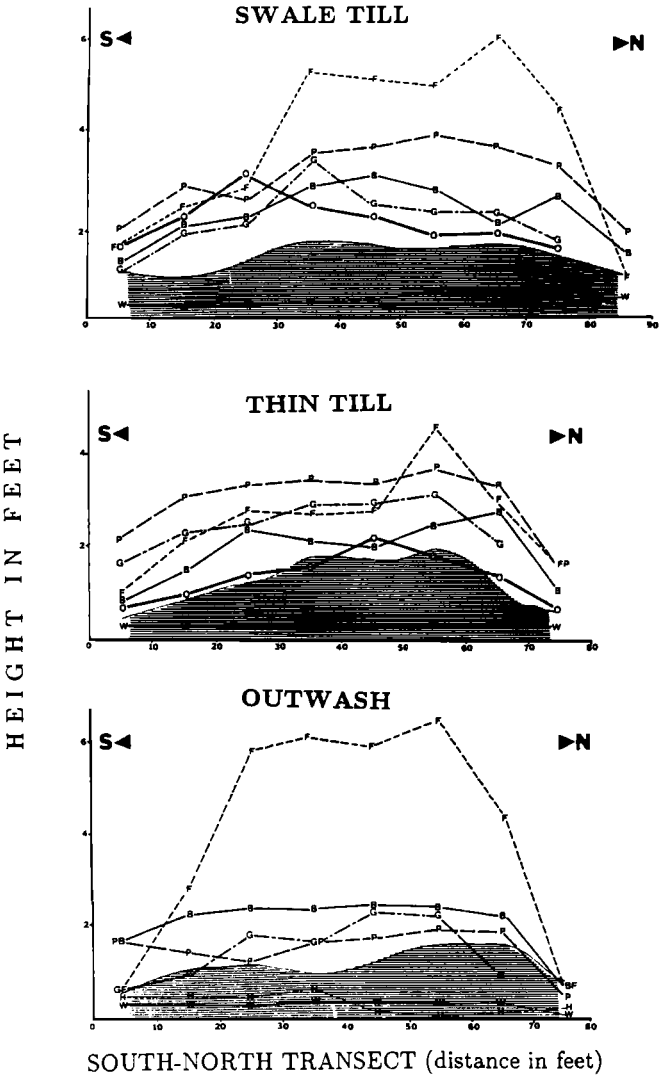



**Figure 1. Average heights of tallest seedlings (up to 5 for each point and species) for the more abundant species at intervals from south to north across clearcut GMF strips at end of second growing season. B=black birch, P=paper birch, G=gray birch, F=pin cherry, H=hemlock, W=white pine. Blackberry-raspberry layer denoted by shading.**

total heights of all trees along north-south transects, 20 ft wide, across the openings on each site. These are depicted in Figures 4 and 5.

## Results

During the first year, all the woody plants that germinated were dominated by short-lived herbaceous annuals, most of which did not appear subsequently.

Figures 1 and 2 show that at the end of the second year the fenced GMF openings were dominated by pin cherry, or sometimes paper birch; on the YTF sites, which were open to deer browsing, gray birch shared dominance. The other birches were of equal height only in the shaded southern edges of the openings. Although most of the area of the openings became covered with blackberry and raspberry bushes, the tops of trees always projected above them.

It is significant that, except for a few black cherry and red

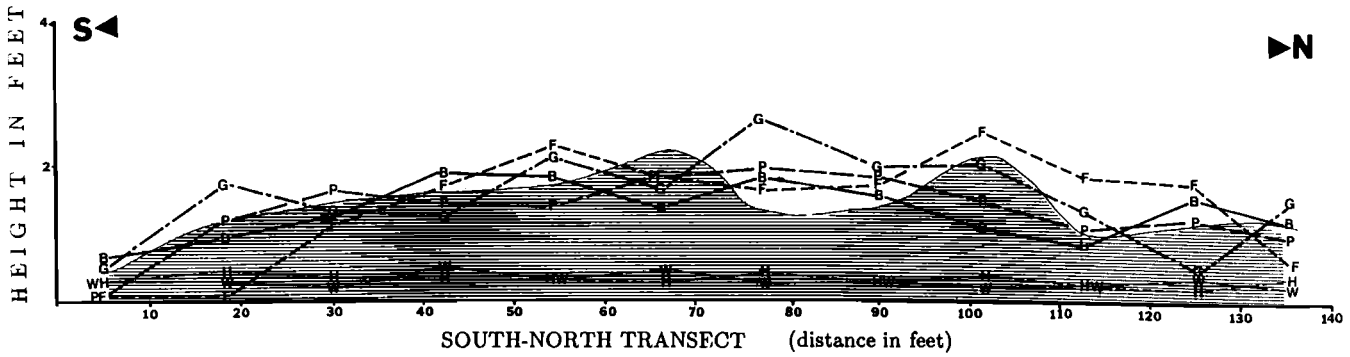



**Figure 2. Same as Figure 1, for transect across opening on thick till at YTF.**

maple, the other hardwood species did not become established anywhere in the openings if they germinated after cutting, even in the zone of diffuse light and side shade at the southern edges. They require even more shaded environments (Marquis 1973).

Figure 3 shows the heights of the tallest trees on the GMF plots in the eighteenth year. The scattered pin cherry that remained and the paper birch shared dominance, but black birch was beginning to gain that position over much of the area, especially near the edges. Both the gray birch and pin cherry were small-crowned and moribund.

Figures 4 and 5 show the relative height growth of various species along the north-south transects. That of the short-lived pioneers had been decelerating or even reversing because of top breakage. No species has been consistently accelerating.

Figures 3, 4, and 5 show some evidence that the height growth of black birch, yellow birch, and red oak was reduced in the centers of the openings where the pioneers, pin cherry, gray birch, and paper birch, had earlier grown the best.

The thin till site had the most diversified species composition, and the 1987 crown profile of a transect (Figure 6) depicts how the various species have become arranged in a stratified mixture. At the eighteenth year most of the enduring species, then in a middle stratum, were still mostly overtopped by comparatively short-lived pioneers. Only at the edges of the openings did the longer-lived black and yellow birches dominate. Red maple, beech, white pine, and hemlock (all comparatively shade-tolerant) remain restricted to an understory stratum.

## Development of Different Species

### Pioneers of the Main Canopy

Blackberries became established throughout all the openings. Raspberries occurred on the YTF till and the GMF outwash sites, where there had been hemlock previously; they were virtually absent on the thin and deep GMF till sites. Where they appeared the raspberries were almost always outgrown by the blackberries, which usually grew slower in height than any tree species except the conifers. The blackberries were closest to ascendancy at the end of the second year. From then until about the seventh year they covered much of the open area, except in the shaded southern edges. By that time they were heavily shaded and disappeared soon afterwards.

Pin cherry, presumably from stored seeds, was initially abundant on all sites. However, it was so severely browsed by deer on the YTF site that it was almost eliminated and its place taken over by birches. On the fenced GMF sites it generally grew faster than the other species until most of it was broken by ice and wet snow in the late winter and spring of 1978 when the trees were 10 yr old. The only places where other species sometimes grew faster were in the side-shade zone at the southern edges of the openings and near the northern edges. Elsewhere each pin cherry generally remained the tallest species until ice or snow broke it.

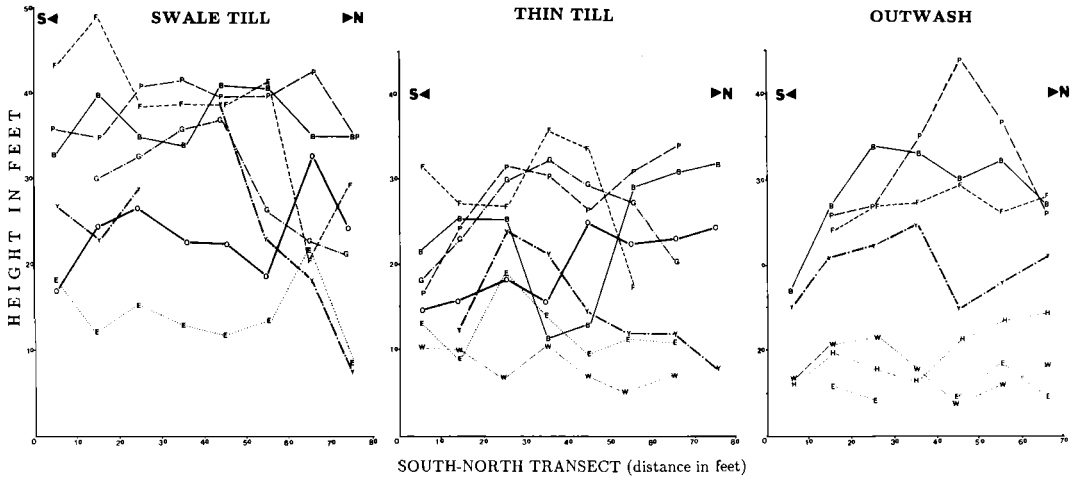



**Figure 3. Average height of tallest trees (up to five for each point and species) for the more abundant species at intervals from south to north across clearcut GMF strips at end of eighteenth growing season. B=black birch, Y=yellow birch, P=paper birch, G=gray birch, F=pin cherry, O=red oak, E=beech, H=hemlock, W=white pine.**

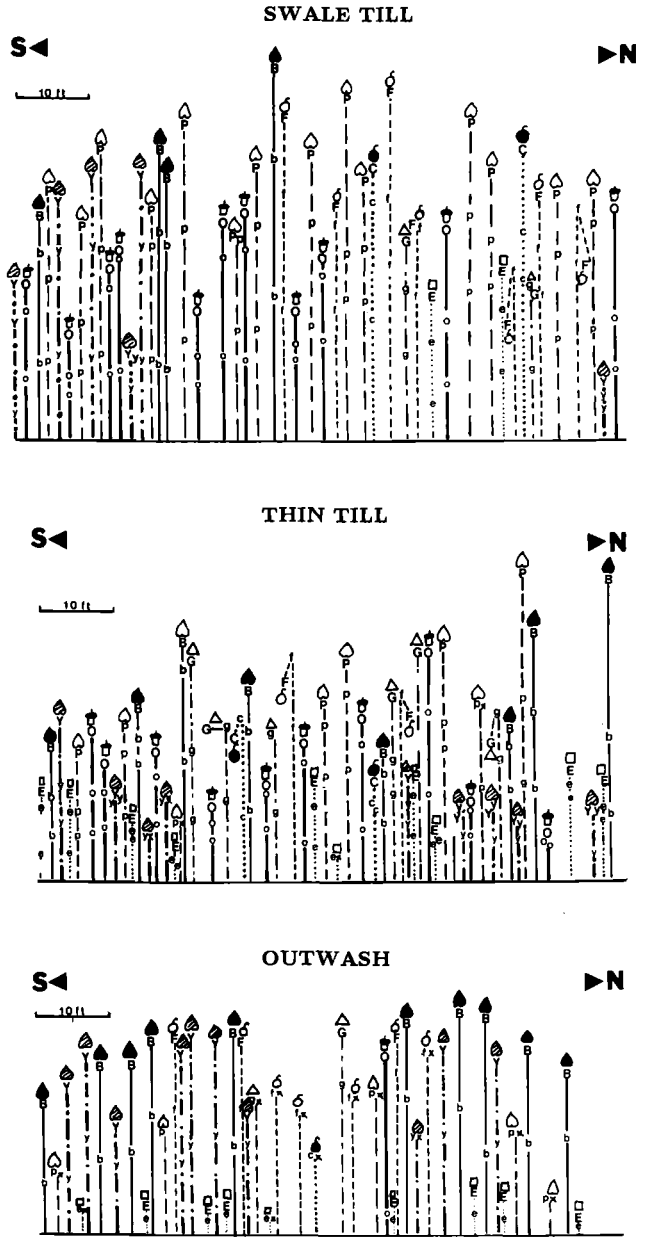



**Figure 4. Height growth of trees on GMF south-north transects. Large capitals denote heights at age 18; smaller capitals, age 13; and lower-case letters, age 7. Letters and characteristically different lines denote species: B=black birch, Y=yellow birch, P=paper birch, G=gray birch, F=pin cherry, C=black cherry, O=red oak, and E=beech.**

Gray birch was sparse on the GMF sites and more abundant on the YTF plot, where much mineral soil had been exposed and also where deer heavily browsed the pin cherry. It generally remained subordinate in height to paper birch and pin cherry wherever they occurred, with one exception. For a decade after the second year it held ascendancy in a zone north of the center of the large circular opening at YFT. Its failure to dominate at any stage on the narrower GMF strip-openings may have been because fencing there allowed pin cherry to dominate or because the strips were not wide enough to allow gray birch to develop. By the eighteenth year virtually all of it had become overtopped, badly broken or bent by frozen precipitation, and moribund.

A few big-toothed and trembling aspens germinated from seed at the scarified YTF site, but they grew more slowly in height than the birches and gradually died. It is probable that they would have been much more prominent if they had originated from root-suckers.

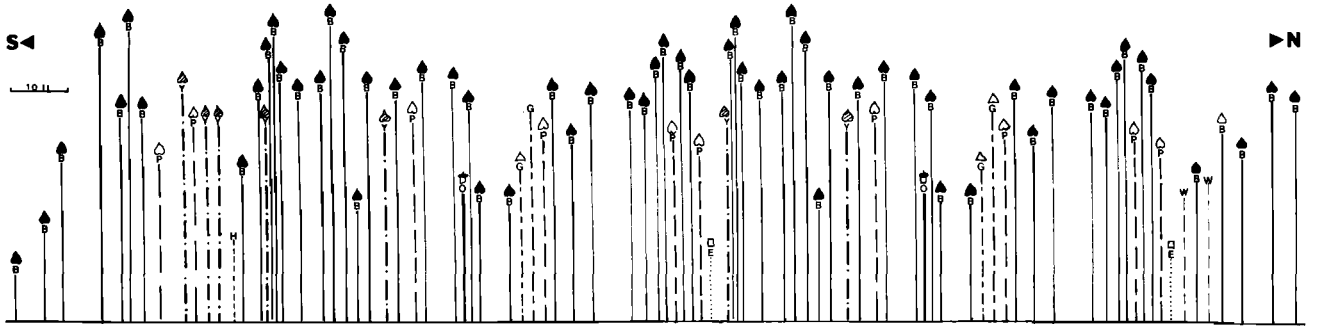
Paper birch germinated almost everywhere; its height growth was generally great during the first few years being equal to or greater than that of gray birch. It was sparse on the outwash site although the few that remained north of the center of the opening were among the tallest trees there. On the unfenced YTF site it suffered from deer browsing and was mostly displaced by black birch. It developed well on the two GMF tills where at the eighteenth year it shared dominance with black birch. Observations in older stands indicate that paper birch ultimately falls behind other species and succumbs, but that had not happened at the eighteenth year.

Red and pitch pine were speedily overtopped by hardwoods and died during the first decade. The tallest was a 10-ft pitch pine near the north edge of the outwash opening.

### Mid-Canopy Species

Black birch was the species most commonly dominant or approaching dominance on all sites near the end of the second decade. It germinated and persisted throughout the openings. In the early stages it was outgrown by pin cherry, gray birch, and paper birch, except in the shaded southern fringes of the openings.

Yellow birch was sparse and generally did not grow as fast in height as the ecologically similar black birch. It tended to be somewhat more common in the shaded southern zones of the openings. In the forests where the studies were made, yellow birch is not common and is usually found on soils that are not as



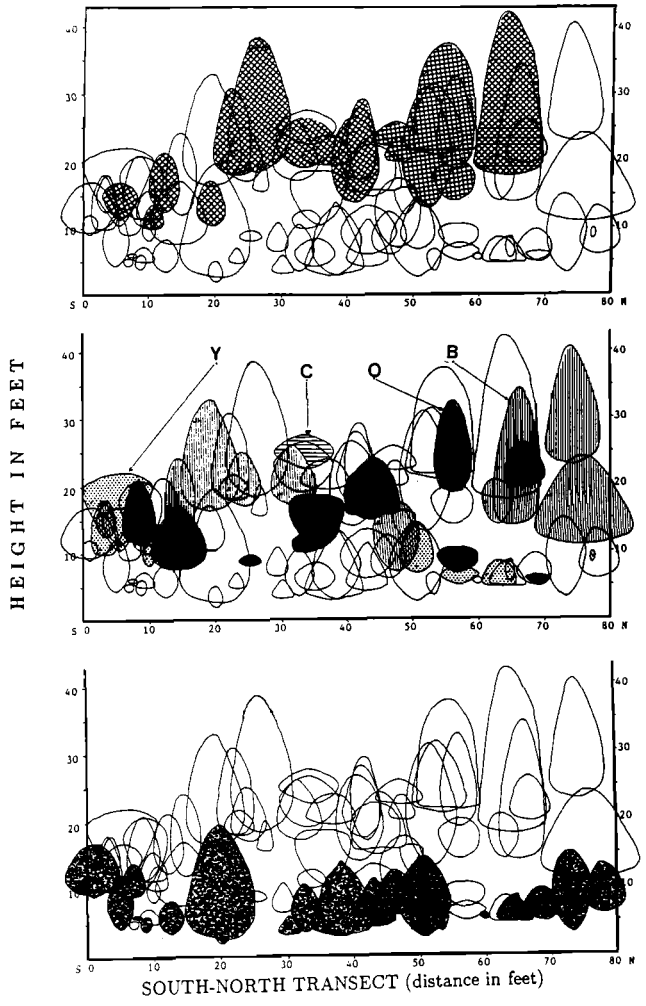



**Figure 6. Crown profile along south-north transect across clearcut strip on thin till at eighteenth year with species of the different canopy strata differentiated. (Top) Pioneers: pin cherry, gray birch, paper birch. (Middle) Mid-canopy stratum: Y=yellow birch; B=black birch; C=black cherry; O=red oak. (Bottom) Lowest stratum: beech, red maple, white pine, hemlock.**

well drained as those of these sites.

The red oaks at the GMF sites were of advanced growth that had germinated before the openings were made. Most of them grew at moderate rates in the middle strata of the stands. At the eighteenth year (Figure 4), few of them were growing as fast in height as their taller birch associates. If the red oaks are going to overtake the birches in the manner observed by Oliver (1977), they have not done so yet. However, some will soon be released when the remaining pin cherry and gray birch die. More will be released if and when the paper birches die.

It is significant that none of these red oaks were more than 1 yr old and 8 in. tall at the time of the removal cuttings. If they had been older and had large root systems, as is typical of most oak advanced growth, they might have grown faster in height. However, most of them seem established even though none met the criterion of Sander and Clark (1971), which defines dependable advanced growth of oak as that which is at least 4.5 ft tall at the time of full release. A few new red oaks have germinated beneath the new stands after vegetative cover was reestablished.

Only a few black cherries, presumably from stored seeds, germinated on the GMF sites. Most on the outwash died. Some persisted in the middle strata on the till plots, and a few may reach the top stratum after some shorter lived species die. Black cherry has kept up with its associates best on the till site.

### Species of Lowest Stratum

Virtually all the beech were on the GMF sites and were root-suckers that did not succumb to efforts to eradicate them. They grew best on the thick till and poorest on the outwash.

Scattered red maple, hemlock, white pine, and red spruce persisted in the lower strata. Red maple generally outgrew the other three. White pine made its best growth beneath gray birch north of the center of the wide opening at YTF. However, it was generally shaded out elsewhere on that deep till site and the one at GMF; it persisted on the thin till and outwash sites.

The hemlocks at YTF all germinated in 1967, but those at GMF were small advanced-growth seedlings reserved in the initial cuttings. Most of the abundant hemlocks at YTF were less than 1 in. dbh at age 21 and thus were not shown in Figure 3 A few small red spruces have persisted near the edges of the opening on the GMF outwash site.

Occasionally new seedlings of red oak, white oak, and white ash have germinated beneath the trees that started in the first year, but none have yet lived more than 3 yr. New hemlock seedlings are, however, able to persist.

## Conclusions

The results of this experiment show that if all advanced growth, stored seeds, and sprout sources had initially been removed from these clearcut openings, the birches would have almost completely dominated subsequent stand development They even suppressed aspen seedlings. Hemlock seedlings would have persisted in the lower strata. It appears that regeneration of the predominant hardwood species of these forests, except for cherries from stored seed and birches, derives from the advanced growth and sprouts that were mostly removed in these experiments. Possibly new seedlings of these other hardwoods would have appeared if more of their seeds had been sown, but their failure is suggestive of a requirement for shade.

In these stands, complete clearcutting with thorough "site preparation" appears to be a form of hardwood silviculture that will produce mostly birches. Furthermore, the best species of these, black, yellow, and paper, are initially overtopped by pioneer pin cherry and gray birch. All four species of birch became established throughout the openings. Their height growth subsequently depended chiefly on their position in the openings and their interaction with each other and with pin cherry.

Pioneer hardwoods, namely pin cherry, gray birch, and paper birch, gained ascendancy in zones where there was direct solar radiation, especially in the widest openings. Black and yellow birch tended to do so in the side-shade zones and at the northern edges where root competition presumably hampered the pioneers. This is consistent with the findings of Linteau (1948), Logan (1965), Marquis et al. (1964), and Marquis (1966) that yellow birch regenerates best in light partial shade while somewhat more exposure favors paper birch.

Wherever it appeared, pin cherry dominated until broken over by frozen precipitation; it was also vulnerable to deer browsing.

When present, 1-yr-old advanced regeneration of red oak grew well enough to occupy the middle stratum beneath the birches.

Black birch grew faster in height on these sites than yellow birch. After 2 decades these two species are replacing dying pin cherries and gray birches. The paper birches are not yet decadent.

Herbaceous vegetation dominated during the first year; blackberry and raspberry cover was almost complete from the second until about the seventh year.

The constituent species did become arranged in strata, but this development was still proceeding at the end of the second decade. Various pioneer species had either disappeared or were in the process of doing so. Subordinate strata of more shade-tolerant species had become well established, but their future development remains to be determined.

These results are consistent with the hypothesis that complete clearcutting, of the kind aimed at securing only natural post-cutting regeneration, in this forest type leads to long periods of dominance by pioneer vegetation. The more desirable species come from advanced growth or sprouts. The establishment of the hardwood species normally considered the most important is probably best sought beneath partial overhead cover.

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