EFFECTS OF SEEDBED, OVERSTORY, AND UNDERSTORY

ON *white ash regeneration*

IN NEW HAMPSHIRE

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U. S. FOREST SERVICE RESEARCH PAPER NE-2
1963

NORTHEASTERN FOREST EXPERIMENT STATION, UPPER DARBY, PA.
FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE
RALPH W. MARQUIS, DIRECTOR

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About the Author...

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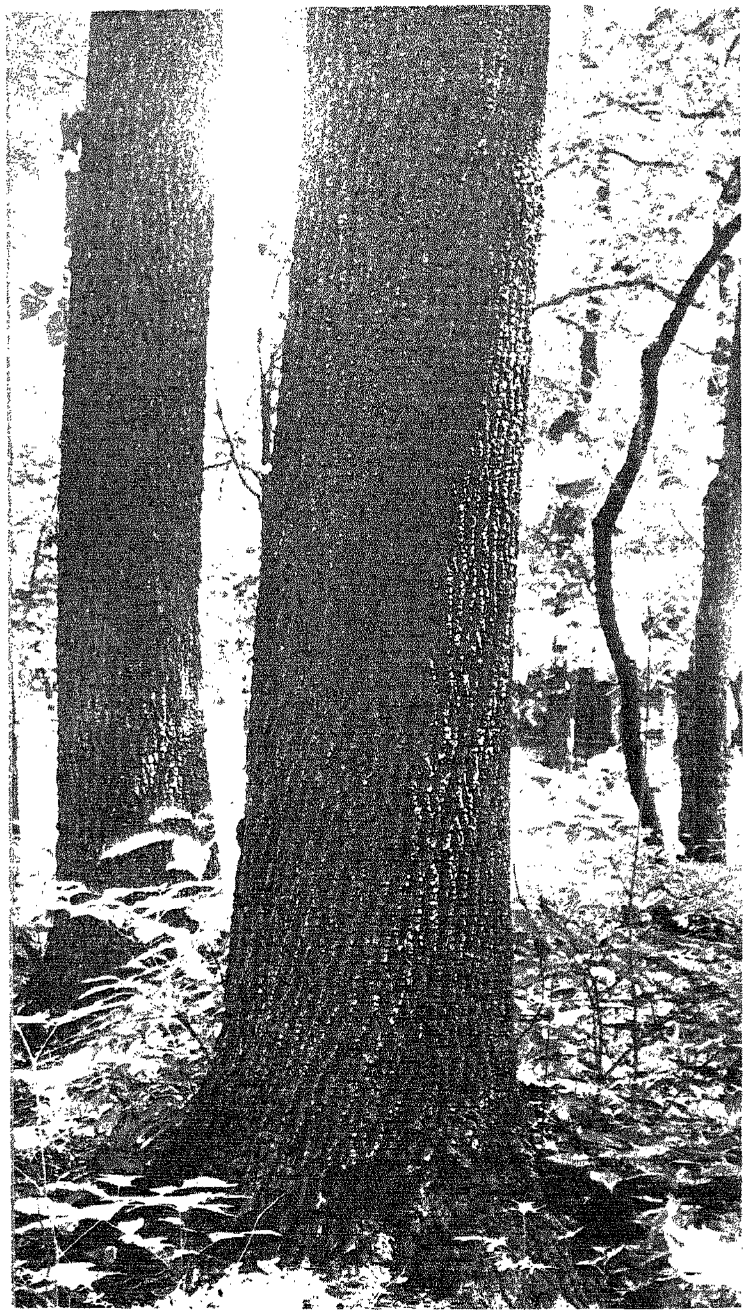

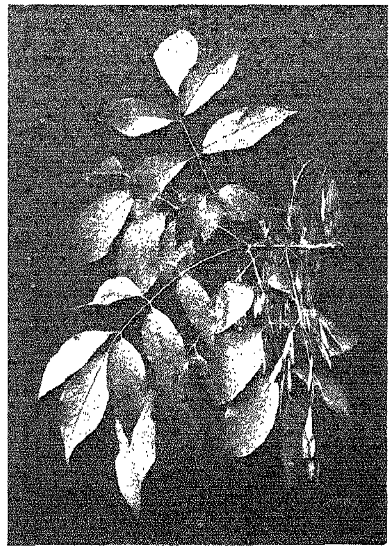

A Species to Encourage

WHITE ASH (*Fraxinus americana*), although only a minor component of New Hampshire's northern hardwood forests, is one of the most desirable species in that forest type. Ash timber is in great demand for baseball bats, tool handles, and various other products in which toughness, elasticity, and resistance to impact are required. In bole form and growth rate, white ash compares favorably with most of its hardwood associates. Given the requisite silvicultural information, forest managers should encourage this species on the moist sites that apparently are most suitable for its growth and development.

However, not much is known about the silviculture of white ash. The little that is known has been learned largely through observation, or as a byproduct from studies of other species. Information is needed particularly on the natural regeneration of the species.[1] As a start toward meeting this need, a small study

[1] Wilson, Robert W. Jr., and Jensen, Victor S. REGENERATION AFTER CLEAR-CUTTING SECOND-GROWTH NORTHERN HARDWOODS. U. S. Forest Serv. Northeast. Forest Expt. Sta. Forest Res. Note 27, 3 pp., 1954.

of the establishment and early growth of white ash regeneration was started on the Bartlett Experimental Forest in New Hampshire in the fall of 1958.

The purposes of the study were twofold. First, we wished to determine how partial cutting and seedbed preparation in a forest stand affect the catch of white ash seedlings. (*Catch*, as used here, means the number of current-year seedlings alive at the end of the growing season.) Second, we wished to determine how partial cutting and undergrowth competition affect the growth of 1-year-old seedlings.

The Study Area

The area used for the study was occupied by an immature stand about 30 years old. Most of the stems were in the range of 3 to 12 inches d.b.h. (diameter breast high); only a few smaller saplings were present. The overstory was predominantly of red maple sprouts, among which were some scattered black cherry, paper birch, white pine, and balsam fir trees. The undergrowth consisted of a rather light cover of ferns, balsam fir seedlings, wild-raisin (*Viburnum cassinoides*), and miscellaneous other low plants.

The site over the entire study area appeared to be rather uniform. The topography was nearly level and without the mounds and depressions that are common under many New England stands. The soil was black with organic matter to a depth of 3 feet; this was underlain by a mottled sandy layer. Drainage was moderate to poor, but standing water was never found there during the growing season, even after a heavy rain. Since white ash in New Hampshire does best on moist sites, the area seemed to be a reasonably favorable one for this species.

There were no ash seed trees in the study area and nearby vicinity. This was fortunate in that it enabled us to keep close control over the seed supply. We could simply hand-sow study plots with given amounts of seed with assurance that no extra seed would blow in from other sources.

Treatments

Partial Cutting

To test the effects of three degrees of overstory density, three degrees of partial cutting were used. In the first, 40 percent of the basal area in trees over 2.5 inches d.b.h. was removed. In the second, 20 percent of the basal area was removed. The third was a control; here no cutting was done. The residual basal areas, in trees over 2.5 inches d.b.h., were respectively 63 square feet, 98 square feet, and 133 square feet.

Each cutting treatment was applied to one square ¼-acre plot in October 1958. Dominant and codominant red maple sprouts, plus a few black cherry trees, made up most of the cut. All bolts and slash were removed from the plots by hand, so the ground was disturbed very little. In ½-chain-wide isolation strips around each plot, trees were girdled to simulate the same degree of cutting that was applied to the enclosed plot. Not all of the girdled trees died completely, but at least foliage density was greatly reduced.

Seedbed Preparation and Sowing

Three seedbed-preparation treatments were tested under each of the cutting treatments, as follows:

1. *Sown-scarified.* — Seeds were sown and then the ground was scarified, which mixed the seeds into the litter and surface soil material.

2. *Scarified-sown.* — The ground was scarified first and then seeds were sown.

3. *Undisturbed.* — Seeds were sown on undisturbed litter.

Scarification in treatments 1 and 2 consisted of chopping and mixing together the litter, surface humus, and some of the upper soil with a Rich fire tool.

These seedbed treatments were assigned at random to three 1/12-acre subplots within each of the three ¼-acre cutting plots. Each subplot was sown with 2.8 pounds of fresh, uncleaned white ash seed from the Bartlett Experimental Forest. This was about 23,300 seeds for each subplot, a rate of some 280,000 seeds per acre. All seedbed preparation and sowing was done immediately after the plots were cut in October 1958.

Understory Treatments

The main surge of germination did not occur until 1960, the second year after the seed was sown. In mid-June 1961, when these 1960 seedlings were 1 year old, three treatments were applied to the competing understory vegetation around selected sample seedlings of the 1960 crop. These treatments were:

1. *Weeding.* — All understory vegetation was completely removed around each sample seedling within a radius of 2 feet.

2. *Bend and clip.* — All understory vegetation taller than 6 or 8 inches within a radius of 2 feet from each seedling was pinned to the ground; smaller weeds and loose ends of pinned plants were clipped off at about two-thirds the height of the ash seedlings. This provided the sample seedlings with full light from above, except as shaded by the overstory, but reduced root competition relatively little. Some reduction in root competition occurred, of course, because of the clipping and other injuries, occasional mortality, and unavoidable interference with growth and transpiration of the bent-over plants.

3. *Control.* — All understory vegetation was left undisturbed.

Three groups of 15 seedlings each were selected in each 1/12-acre subplot, and the three understory treatments were assigned among seedling groups within subplots at random. Essentially constant competitive conditions were maintained through the 1961 growing season by re-treating as required at about weekly intervals.

When treated in June 1961 the ash seedlings averaged about 2½ inches tall, and had just begun to leaf out. The undergrowth was fairly light on the uncut plot but heavy on the partially cut plots. Heavy growth on the latter plots was to be expected, considering that two growing seasons had elapsed since cutting. This understory vegetation, consisting of cinnamon fern, raspberry, and several other species, averaged around 2 to 2½ feet in height.

Measurements

Numbers of seedlings were estimated at the end of the first and second growing seasons (1959 and 1960). For each estimate, two random strips of 14 milacres each across each subplot were tallied; this amounted to a 33.6-percent sample of the area. Strip locations in 1959 and 1960 were not the same. In 1960, 1-year and 2-year seedlings were tallied separately.

On the 405 seedlings where the competitive understory was treated, heights were measured immediately after treatment in June and again in September 1961. Measurements to the nearest 1/20 inch were taken between a black inkspot placed at the root collar and the tip of the stem or terminal bud. Also, in September, stem diameters ½ inch above the root collar were measured to the nearest 1/64 inch with a micrometer.

Soil moisture, as a percentage of oven-dry weight, was determined from samples taken weekly from June 26 through August 28 in each understory-overstory treatment combination. Only the upper 3 inches of soil were sampled. Since the physical effects of the seedbed treatments had practically disappeared by 1961, this variable was not sampled. All samples were taken from the three sown-scarified subplots, which were assumed to be fairly representative of all subplots under each overstory condition. At each sampling, soil was taken separately adjacent to each of two seedlings in each of the nine understory-overstory treatment combinations—a total of 18 samples per week.

Results

Seedling Catch

A fairly good catch of white ash seedlings appeared in 1959, the first year after sowing. However, many more seedlings appeared in 1960 from seed that had remained dormant through the first year. This second-year catch varied among cutting treatments (all seedbed treatments combined) from about twice the first-year catch to five times as much; among seedbed treatments even greater differences occurred.

We cannot explain this seed dormancy; in fact, we are not sure whether such a high degree of delayed germination is characteristic of the species or is an unusual event. Nor can we explain why the ratio of second-year to first-year seed catch varied so much among cutting and seedbed treatments. A scattering of new germinates appeared on the study area during the summer of 1961 from seed that had lain dormant for 2 years. However, the

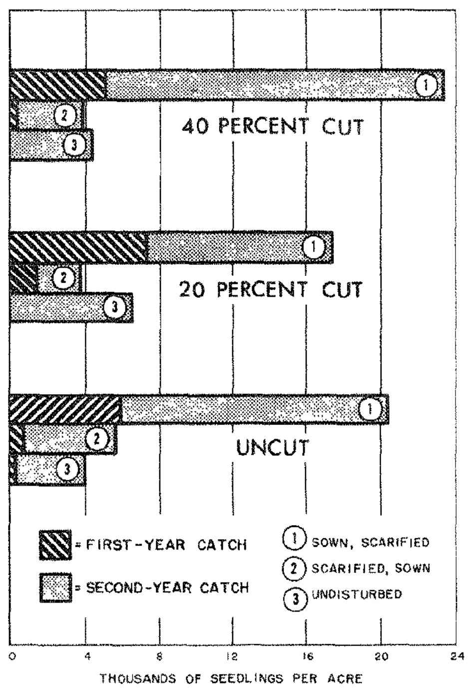

Figure 1. — Numbers of white ash seedlings per acre, showing effects of cutting intensity and seedbed treatment.

third-year catch was relatively small—no more than 500 to 600 trees per acre as compared to earlier catches running into the thousands. And since these seedlings were so far behind the advance growth, they stood little chance of coming through. Hence we have confined the following discussions to the first-year and second-year catches only.

The first-year catch varied with cutting treatment and seedbed treatment. Chi-square tests indicated that overall differences for both variables were highly significant (0.01 level). Among cutting treatments (all seedbed treatments combined), the 20-percent cutting was best, followed by the uncut control and then by the 40-percent cutting. However, the differences among cutting treatments were not large enough to be of much practical importance. Among seedbed treatments, the sown-scarified treatment was by far the best, followed by the scarified-sown treatment and then by the undisturbed control (fig. 1).

The second-year catch also varied with cutting and seedbed treatments; overall differences again were highly significant. But the ranking of the cutting treatments now—as compared with the ranking for the first-year catch—was reversed: now the 40-percent cutting had the largest catch, and the 20-percent cutting had the smallest. Among seedbed treatments, the sown-scarified plot again had a far larger catch than the others (fig. 1).

Considering the first- and second-year catches combined, we can generalize on cutting and seedbed treatment results as follows: Differences among cutting treatments (all seedbed treatments combined), although significant at the 0.05 level, were not great enough to be of much practical importance. The ratio of numbers of seedlings was about. 1.1/1.1/1.0, respectively, for the 40-percent cutting, the uncut control, and the 20-percent cutting. Of the three seedbed treatments (all cutting treatments combined), the sown-scarified treatment produced by far the largest total catch; the ratio of numbers of seedlings was about 4.6/1.1/1.0 respectively for the sown-scarified, undisturbed, and scarified-sown seedbeds. Probably better coverage of the seeds with soil accounts for the larger catches with the sown-scarified treatment; this coverage undoubtedly provided a more plentiful and less variable moisture supply for stratification and germination than was available to uncovered seeds. Also, the covered seeds may have been exposed less to rodent damage.

Mortality

Although the study did not include a direct tally of mortality, differences between the estimated numbers of 1-year seedlings in the fall of 1959 and 2-year seedlings in the fall of 1960 provided some indication of mortality during that period.

Except for a loss of about 11 percent under the 40-percent cutting, mortality was low for all cutting and seedbed treatments. The greater losses under the 40-percent cutting possibly were due, at least in part, to higher air and soil temperatures than occurred under the heavier canopies. Small cankers that appeared to have been caused by excessive heat were found at the root collars of several seedlings.

Competition and Growth

The height-growth data presented here pertain only to growth that occurred on 1-year-old seedlings from mid-June, when the understory treatments were applied, to September of the same year. The figures thus do not represent total growth for the season.

The sample seedlings made relatively little height growth during the period of observation; averages by treatments were no more than ⅔ inch. However, some individual seedlings grew

Table 1. — Average height growth of 1-year white ash seedlings from mid-June to September, by overstory and understory treatments

Understory treatment	Percentage of overstory cut					
	40		20		0	
	Inches	*Percent*[1]	*Inches*	*Percent*[1]	*Inches*	*Percent*[1]
Weeding	0.39	14.1	0.61	22.0	0.24	9.2
Bend-and-clip	.42	17.6	.67	24.0	.26	10.7
Control	.19	7.7	.34	12.7	.14	6.1

[1]Growth percentages are based on heights at the start of the observation period in mid-June.

as much as 2 inches. Despite the small amount of average growth, several consistent or significant differences were evident.

Among cutting treatments, average height growth consistently was highest under the 20-percent cutting, intermediate under the

40-percent cutting, and lowest in the uncut stand. Growth in both inches and percentages—regardless of understory treatment—consistently followed this pattern (table 1). Since the cutting plots were not replicated, the figures are not well suited to statistical analysis, and one must be cautious in interpreting the data. But because the plots are so similar in topography, drainage, and soils, we believe that these growth differences must have resulted to a large extent from environmental differences induced by the cutting treatments.

Average height growth also varied with understory treatment. Height growth (in both percentages and inches) was roughly twice as much for the weeding and bend-and-clip treatments as for the untreated controls (table 1); and the differences were highly significant at the 1-percent level. The bend-and-clip treatment resulted in slightly but consistently more growth than the weeding, but differences between these two treatments were not significant.

By removing the undergrowth, the weeding treatment produced three changes in the seedlings' environment:

1. The seedlings were freed from competition for light (except from the overstory).

2. Losses of water through transpiration of the undergrowth were eliminated.

3. Evaporation from the ground surface probably was increased.

The bend-and-clip treatment also freed the seedlings from competition with the understory for light. But, in contrast to the weeding, the bend-and-clip treatment probably caused only slight to moderate changes in transpirational losses and evaporation from the ground. The fact that height growth under the weeding and bend-and-clip treatments was nearly the same implied that soil moisture under these treatments also was about the same; and this implication was confirmed by soil moisture determinations. Evidently increased evaporation from the bare soil in the weeding treatment just about balanced transpiration from the living plants in the bend-and-clip treatment.

The measurements of final stem diameter of ½ inch above the root collar indicated that height growth was not made at the expense of diameter growth. The cutting and understory treatments that produced the most rapid height growth tended to produce the largest or at least comparable diameters.

Soil Moisture

Soil moisture generally was higher under the 20-percent cutting than under the other two cutting treatments, except after mid-August when it dropped slightly below that of the other treatments. Soil moisture under the 40-percent cutting tended to be slightly but not substantially higher than under the uncut stand (fig. 2). Differences among the three understory treatments were small and inconsistent.

We cannot explain all the whys of the soil-moisture data, particularly why moisture under the 20-percent cutting ran higher than under the 40-percent cutting. Unrecognized variations in the content of organic matter possibly were involved. Since the

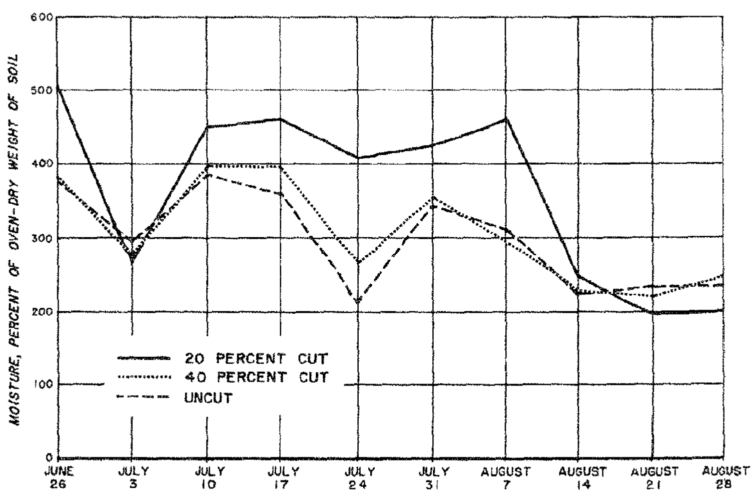

Figure 2. — Average soil moisture on the study plots in summer 1961. Based on oven-dry weight.

cutting treatments were not replicated, we cannot safely conclude that cutting intensity was responsible for the observed differences in soil moisture.

However, a noteworthy correlation occurred between soil moisture and seedling growth under the three cutting treatments: both moisture and growth were highest under the 20-percent cutting and lowest under the uncut stand. So, regardless of whether or not the higher soil moisture under the 20-percent cutting was a true effect of this cutting intensity, the higher moisture in conjunction with the moderate increase in light did produce the best height growth. Presumably the lower soil moisture under the 40-percent cutting was a limiting factor that prevented seedlings there from fully utilizing the stronger light available to them.

Discussion

Because this study was very limited in scope, we cannot offer any definite rules on how to regenerate white ash. But some information was acquired that should be of practical value to those who are interested in white ash regeneration. Until more information is available, our results should be considered applicable only on moist, highly organic soils in the White Mountains of New Hampshire.

The study results indicated that, to obtain a good catch of seedlings, the seeds should be well covered with soil. In practical woods operations, this might be accomplished by tractor-logging during late fall of a good seed year after seed dissemination, making sure that most of the ground is thoroughly disturbed by the skidding operations.

A substantial proportion of the ash seed in this study remained dormant over two winters before germinating. Since the seed was collected from only a few seed trees, we are not sure whether or not this extended dormancy is characteristic of the species. Until more information is available, surveys of the seedling catch on an area should be delayed until the end of the second growing season after seed dissemination.

The limited mortality, growth, and soil-moisture data all consistently indicated that removal of some of the overstory improved the environment for ash seedlings during their first 2 years of life, and that a comparatively light cutting (20 percent of the basal area) was better than a heavier (40 percent) cutting. Although observations were not extended beyond 2 years in this study, removal of considerably more than 20 percent of the overstory probably would favor growth of the ash seedlings after they were well established.

With opening of the overstory, herbaceous and shrubby understory vegetation was stimulated and became highly competitive with the ash seedlings. This competition was mainly for light. When the shading effect of the understory vegetation was eliminated, whether the competing plants were physically removed or merely bent aside, the growth response of the ash seedlings was about the same.

Our observations of understory competition point up the importance of avoiding or controlling this competition in field operations aimed at regenerating white ash. Unfortunately, our experimental treatments were not practical field treatments. Practical methods for coping with understory competition remain to be worked out.

Summary

A small plot study of the effects of partial cutting of the overstory, seedbed treatment, and understory competition on germination and early development of white ash seedlings was conducted in the White Mountains of New Hampshire. All plots were hand-sown with equal amounts of seed.

Because of extended seed dormancy, the catch of seedlings during the second growing season after sowing was considerably greater than the first-year catch, and a few seeds germinated during the third growing season after sowing.

Cuttings of 0, 20, and 40 percent of the overstory basal area had little effect on total seedling catch. Height growth of 1-year-old seedlings was stimulated to some extent by partial cutting, and was rather consistently better under the 20-percent cutting than under the 40-percent cutting.

Scarification of the seedbed after sowing produced a much greater total seedling catch than pre-scarification or no seedbed treatment. Apparently covering of the seed with soil was highly beneficial to germination.

One-year-old seedlings that had been released from understory competition either by complete removal of the surrounding vegetation or by bending this vegetation down grew somewhat faster in height than unreleased seedlings. Soil moisture was not consistently altered by these treatments; the main limiting factor apparently was light.