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GROWTH OF WHITE PINE SEEDLINGS BENEATH AN ASPEN STAND

by

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CONTENTS

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K. T. LOGAN[1]

INTRODUCTION

Before 1900, old stands of white pine[2] were common on sandy soils in the Great Lakes-St. Lawrence Forest Region in Ontario (Rowe 1959). Most of these stands have been cut or burned and less valuable species such as aspen or white birch have often replaced the pine. In some areas seed for pine regeneration is still available from scattered mature pine, but young stands of pine are not common.

On dry sites the ability of the seedling to compete for both soil moisture and light probably determines whether pine will establish itself, but on moist sites where the undergrowth is more luxuriant the critical factor is generally light. Two questions commonly posed are: 1) how much light do young white pine need to grow well, and 2) would light be adequate if either aspen or the undergrowth were removed.

These problems have been investigated recently at the Petawawa Forest Experiment Station, Chalk River, Ontario. An experiment conducted in a nursery showed that height growth of 4– to 8–year-old white pine seedlings responded to increases in light up to 55 per cent of that prevailing in the open (Logan 1959). Another study showed that a dense understorey suppresses young white pine (Logan and Farrar 1953). The objective of the present study was to evaluate the relative influences of an aspen overstorey and undergrowth on white pine seedlings.

METHOD

Experiment Area

The area chosen for the experiment is typical of many in the white pine region of Ontario. The original stand of white pine was destroyed by fire in 1870 and replaced with white birch and trembling aspen. This stand was in turn burnt in 1923 and gave rise to the present stand of aspen. Surrounding the 40-acre area are scattered mature white pine trees which survived the fires. Most of the stand was thinned in 1936, leaving 800 aspen per acre, and underplanted the following year with white pine seedlings. Logan and Farrar (1953) have reported the failure of this underplanting.

The soil is mostly medium to fine sand interbedded with silty material. The soil moisture regimes were rated on the basis of topography, soil profile, and minor vegetation, as fresh, moist, and very moist, which may be equated roughly to symbols 3, 4, and 5 in Hills' classification (Hills 1952).

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[2] Botanical names are given in the Appendix.

The undergrowth competing with the pine seedlings differed on each moisture regime (see Figures 1, 2 and 3). On the fresh site it was mostly clumps of hazel 3 to 4 feet tall, and pine seedlings had invaded a few of the scattered openings. On the moist site, hazel was 6 feet tall (red maple, wild-raisin, and mountain holly were vigorous competitors) and few openings occurred. Undergrowth on the very moist site consisted of wild-raisin and mountain holly with scattered hazel and winterberry and a dense cover of interrupted fern, bracken, and spinulose wood fern.

Design of Experiment

In designing the experiment, four blocks were established on each of the three sites. A split-plot layout was used with treatments arranged in 20–foot squares. Treatments were: clear cut overstorey trees and undergrowth, cut undergrowth only, cut overstorey only, and control (cut neither overstorey nor undergrowth).

Each clear-cut plot resembled a small opening in a forest. Some trees were cut in an irregular pattern adjacent to the plot in an effort to keep this opening clear of shade for 6 hours in the middle of the day. Undergrowth was cut back each year as required.

FIGURE 1. Typical vegetation on a control plot with a fresh moisture regime.

FIGURE 2. On the moist sites, tall shrubs and red maple predominate.

Fourteen 4–0 white pine seedlings of local origin were planted on each of the 48 plots in 1951. These seedlings were of uniform thrift and size and were selected so that their average height was 1.1 feet and mean heights differed between treatments by only 0.1 feet.

Instrumentation

Instruments were placed on the four plots of one representative block in each moisture regime. The purpose of instrumentation was to indicate relative differences in air temperature, evaporation, soil moisture, and light between treatments, to help explain differences in seedling growth.

Air temperature and evaporation 1 foot above ground were measured with minimum-maximum thermometers and Piché evaporimeters respectively. These instruments were read daily from June 1 to August 31.

Relative soil moisture data were obtained from stacks of Colman units installed at 6-inch intervals in cores of a uniformly mixed silty sand in which each unit had been calibrated. Units were read twice weekly during the summer months except during dry weather when they were read daily. Objections may be raised to using a uniform soil rather than the soil *in situ*, but this method had the advantage of enabling accurate calibration of each unit by using the sunflower test as an indicator of wilting point, thus allowing valid comparisons between units. In this report the criterion for the relative effect of cutting treatment on soil moisture is the number of days that units in the test soil registered permanent wilting point.

Effect of treatment on quantity of light 18 inches above ground was measured with spherical illuminometers that have a spectral sensitivity similar to that of the human eye (Logan 1955). These instruments integrate the quantity of light received on a spherical surface over a period of time. Readings were made on clear sunny days between 9:00 a.m. and 4:30 p.m. Procedure was to place one instrument at a representative spot on each of the four plots on one block and a fifth instrument in a nearby open area. The instruments were read simultaneously at hourly intervals and the quantity of light on each plot was expressed as a percentage of that in the open.

Measurements of Seedlings

Measurements of seedlings made in 1955 form the basis of this report and reveal the effect of cutting treatment on growth of seedlings on each site. Measurements included total height, leader diameter (measured at the midpoint), and needle length (using needles on the leader).

FIGURE 3. A control plot on a very moist site. Note the dense cover of ferns and shrubs.

RESULTS

Effect of Treatment on the Environment

Mean maximum temperatures increased with increasing light, and differences between clear-cut and control plots ranged from 6° to 15° F. (Tables 1 and 4). On individual days these differences were occasionally as high as 18° F. Mean minimum temperatures were similar on all sites and treatments. Temperature maxima were usually higher on the fresh site than on the other two. The year 1954 was relatively cool and wet.

TABLE 1. MEANS OF DAILY MINIMUM AND MAXIMUM AIR TEMPERATURE, MEASURED 1 FOOT ABOVE GROUND—JUNE 1 TO AUGUST 31.

Cutting treatment	Fresh		Moist		Very Moist	
	Min.	Max.	Min.	Max.	Min.	Max.
1952						
Clear cut	48	91	48	89	48	88
Undergrowth cut	47	89	47	86	50	87
Overstorey cut	48	84	49	85	50	82
Control	48	85	49	81	50	78
1953						
Clear cut	49	91	49	87	48	89
Undergrowth cut	49	85	48	85	50	83
Overstorey cut	50	81	50	78	50	78
Control	50	81	49	81	51	74
1954						
Clear cut	50	82	49	79	49	81
Undergrowth cut	50	78	49	76	50	75
Overstorey cut	51	74	49	74	50	73
Control	50	74	49	72	50	70
1955						
Clear cut	52	91	52	86	51	87
Undergrowth cut	52	86	51	82	52	84
Overstorey cut	52	80	52	81	52	81
Control	52	81	52	79	52	78

Daily evaporation from the evaporimeters was barely affected by removing aspen but increased by as much as 50 per cent when undergrowth was cut (Table 2). This was probably owing more to better ventilation than to an increase in light. The effect of a cool wet year is apparent from the low evaporation in 1954.

TABLE 2. MEANS OF DAILY EVAPORATION IN CC'S AT THE 1-FOOT LEVEL FROM JUNE 1 TO AUGUST 31.

Cutting treatment	1952			1953			1954			1955		
	F[1]	M	VM	F	M	VM	F	M	VM	F	M	VM
Clear cut	3.3	2.7	2.4	2.5	2.4	2.0	1.5	1.3	1.2	2.3	2.2	1.8
Undergrowth cut	3.0	2.3	2.3	2.4	1.9	2.0	1.3	1.1	1.1	2.1	1.9	1.6
Overstorey cut	2.2	2.0	1.7	1.9	1.3	1.1	0.8	0.7	0.7	1.0	1.0	1.1
Control	2.4	2.0	1.5	1.8	1.2	1.3	0.9	0.8	0.8	1.5	1.4	1.2

[1] The letters F, M and VM denote fresh, moist and very moist sites respectively.

Rainfall was recorded at Station Headquarters (4 miles distant) in 1952 and on a clear-cut plot for the remaining years. Rainfall in inches from June 1 to August 31 was as follows (figures in brackets refer to percentage of 20-year average rainfall):

1952	8.7	(89.7)
1953	6.3	(64.9)
1954	12.2	(125.8)
1955	6.4	(66.0)

Table 3 indicates the number of days in 1953 and 1955 on which successively deeper zones of the test soil reached permanent wilting point (PWP). In 1954 rainfall was heavier than normal and none of the Colman units registered PWP. Distribution of rainfall in the other 2 years was such that wilting on the plots as a whole was not likely to be more prevalent than on the test soil. Except in the clear-cut plot on the moist site, which was heavily invaded by grass, the test soil was at PWP for a longer period and to a greater depth on the control than on the treated plots. Rarely was all the soil in the top 18 inches at PWP in any plot and periods of stress came late in the season when growth was largely completed. If we assume that seedlings were exploiting the top 18 inches of soil (most seedlings had roots longer than 12 inches when planted) then soil moisture was rarely critical on any treatment.

The effect of cutting treatment on quantity of light on a clear sunny day is shown in Table 4. A day without some haze or cloud formation in the afternoon is rare at Petawawa and these figures were recorded on the 3 best days on which readings were attempted. Measurements were made about 18 inches above ground. Neighbouring stands had considerable influence on light on the plots particularly on the clear-cut plot on the moist site. This latter measurement is undoubtedly atypical of these plots because it is not reflected in a corresponding decline in seedling growth. Removing the undergrowth had a substantially greater effect on light than removing the aspen. Cutting aspen increased light at the seedling level only when undergrowth was also cut. Light on plots without undergrowth ranged from 21 to 65 per cent compared with less than 5 per cent on plots with undergrowth. Note that the shading effects of undergrowth and overstorey are not additive, largely owing to mutual overlapping.

TABLE 3. NUMBER OF DAYS ON WHICH SUCCESSIVELY DEEPER ZONES OF THE TEST SOIL REACHED PERMANENT WILTING POINT, JUNE 1 TO AUGUST 31.

Cutting treatment	Depth in inches	1953			1955		
		F	M	VM	F	M	VM
Clear cut	0-1	13	2	0	5	14	3
	0-6	13	2	0	3	11	0
	0-12	0	0	0	3	10	0
	0-18	0	0	*	0	5	*
	0-24	0	0	*	0	0	*
Undergrowth cut	0-1	8	0	0	6	0	0
	0-6	8	0	*	6	0	*
	0-12	0	0	*	5	0	*
	0-18	0	*	*	5	*	*
	0-24	0	*	*	0	*	*
Overstorey cut	0-1	1	0	8	10	0	29
	0-6	1	0	*	5	0	*
	0-12	0	0	*	0	0	*
Control	0-1	13	0	4	16	0	29
	0-6	13	0	*	10	0	*
	0-12	8	0	*	6	0	*
	0-18	4	*	*	6	*	*
	0-24	0	*	*	1	*	*
	0-30	0	*	*	0	*	*

* No Colman units at these depths.

TABLE 4. MEAN QUANTITY OF LIGHT MEASURED 18 INCHES ABOVE GROUND FROM 9:00 a.m. TO 4:30 p.m. DURING 3 CLEAR DAYS EXPRESSED AS A PERCENTAGE OF LIGHT IN THE OPEN.

Cutting treatment	Moisture regime		
	Fresh	Moist	Very moist
Clear cut	65	27	64
Undergrowth cut	36	32	21
Overstorey cut	3	3	4
Control	4	3	1

These instrumentation data describe differences in some environmental factors on the plots. The most important differences were in light and temperature. Of these two, light probably had the greatest effect on growth because it ranged from an adequate amount to values generally accepted as below minimum, whereas the range of temperatures encountered was well within the tolerance of the species.

Seedling Growth

Surplus seedlings were planted to allow for mortality, but 40 per cent of the seedlings were damaged by browsing and blister rust making the statistical analysis originally planned unfeasible. However, the main conclusions to be drawn from the results were clearly apparent. Measurements from all replicates were combined and growth responses are discussed in terms of mean height, mean diameter, and mean needle length for each of the cutting treatments and moisture regimes (Table 5). Rank tests (Wilcoxon 1949) were applied to these data, and in the following discussion significance is at the 98 or 99 per cent level as indicated by these tests.

On each site, removing aspen alone from a small plot had no appreciable effect on height but when undergrowth was removed height increased significantly regardless of the aspen overstorey. Leader diameter also increased when undergrowth was cut and in contrast with height, a further significant increase occurred when both undergrowth and aspen were cut. Needle length was not affected by aspen but needles on fresh and very moist sites were significantly longer when undergrowth was cut.

TABLE 5. THE EFFECT OF CUTTING TREATMENT ON HEIGHT, LEADER DIAMETER, AND NEEDLE LENGTH.

Cutting treatment	Height			Leader diameter			Needle length		
	F	M	VM	F	M	VM	F	M	VM
	(ft.)			(mm.)			(ins.)		
Clear cut	3.0	2.9	2.9	3.7	3.2	4.0	2.8	2.5	2.9
Undergrowth cut	2.7	2.7	2.6	3.1	2.9	2.7	2.6	2.4	2.8
Overstorey cut	2.3	2.3	2.0	2.3	2.2	1.8	2.4	2.4	2.2
Control	2.3	2.0	1.9	2.2	1.9	1.7	2.2	2.3	2.3

Moisture regime had no apparent direct effect on height of seedlings. Seedlings growing on control plots and plots with overstorey removed were shorter on the very moist sites than those on the drier sites, but this was attributed to lower light beneath the denser undergrowth typical of the wetter plots. Leader diameters beneath the undergrowth were also significantly smaller on the very moist sites, probably for the same reason. Needle length was unaffected by differences in moisture regime.

Comparisons between treatments in this experiment and those in the Petawawa nursery mentioned earlier (Logan 1959) are difficult to make, largely because light varied more in time and space beneath the stand than in the nursery shelters. Light conditions existing on the clear-cut plots were approximately similar to those in the shelters admitting 55 per cent light in the nursery, and also there was close similarity between plots with only the undergrowth cut and the shelters admitting 22 per cent light. Light in the remaining two field treatments was less than 5 per cent, which was considerably less than the minimum light in the nursery experiment. It is interesting to note the similarity in size of seedlings growing in roughly similar quantities of light under field and nursery conditions (Table 6).

TABLE 6. GROWTH OF WHITE PINE SEEDLINGS UNDER VARIOUS QUANTITIES OF LIGHT IN THE NURSERY (N) AND IN THE FIELD ON A FRESH SITE (F).

Per cent light		Height		Leader diameter		Needle length	
N	F	N	F	N	F	N	F
		(ft.)		(mm.)		(ins.)	
100		3.4		5.0		2.5	
55	65	3.1	3.0	4.0	3.7	2.8	2.8
22	36	2.5	2.7	3.1	3.1	2.5	2.6
19		2.6		3.1		2.9	
14		2.0		2.4		2.8	
	3		2.3		2.3		2.4

DISCUSSION

On the three moisture regimes studied, seedlings were suppressed by undergrowth rather than aspen. Shirley's (1945) findings were similar. The results suggest that if undergrowth is cut, the presence of large aspen will not seriously affect height growth of seedlings but will result in smaller leader diameters and hence may reduce susceptibility to weevil attack. Aspen may also improve nutrition of pine seedlings (Stoeckeler 1961).

There was less than 5 per cent light beneath the undergrowth regardless of whether the overstorey was cut or not, and poor growth was attributed to this factor. When the undergrowth alone was removed, light amounted to 21–36 per cent beneath the aspen, and seedlings grew well. Atkins (1957) found satisfactory growth on white pine seedlings growing in 25 per cent light.

When undergrowth and aspen were both removed from a small plot, light ranged from 27–65 per cent. This indicates the amount of shading to be expected in a small opening in the forest. Conceivably seedlings in this treatment might have been taller had the clearings been large enough to admit full light, but Shirley (1945) and Logan (1959) have both reported little increase in height growth of white pine above 45 and 55 per cent light respectively. It is also questionable whether enlarging the clearings would have increased the quantity of light beneath the undergrowth where light was measured and the seedlings growing.

Differences in moisture regime had no direct effect on the seedlings: apparently the very moist site was not too wet nor the fresh site too dry to affect growth during the experiment. But moisture influenced growth indirectly through the varying density of vegetation present on each site.

The comparison of seedlings grown in the field experiment with those in the nursery suggests that the greater root competition in the field has had little effect on growth; it may have been offset by additional soil moisture, although other factors such as nutrition may also have been involved.

Logan and Farrar (1953) have already shown that on moist sites with luxuriant undergrowth pine could not be successfully planted under aspen even when the overstorey had been thinned. The present study indicates that underplanting 30–to–40–year-old aspen with white pine may be practical, at least on fresh to very moist sites with sandy soils, when combined with removal of undergrowth. As in any white pine plantation, some protective measures to combat browsing and blister rust may be necessary.

SUMMARY

White pine seedlings growing beneath aspen were studied on three sites. Height growth increased following removal of the undergrowth whereas removal of aspen alone had little effect on height. Cutting undergrowth and aspen resulted in larger leader diameters.

Light increased from less than 5 per cent to 21–36 per cent when undergrowth was cut, and to as much as 65 per cent when aspen was also cut. Mean maximum air temperature increased with light.

It is concluded that white pine can be grown beneath aspen on fresh to very moist sandy soils with little reduction in height if undergrowth is controlled until the seedlings are 4 to 5 feet tall. Overstorey aspen 30 to 40 feet tall may even be beneficial in reducing the incidence of weevil attack and in improving seedling nutrition.

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APPENDIX

COMMON NAME	SCIENTIFIC NAME
Aspen, trembling	*Populus tremuloides* Michx.
Birch, white	*Betula papyrifera* Marsh.
Maple, red	*Acer rubrum* L.
Pine, white	*Pinus strobus* L.
Fern, bracken	*Pteridium aquilinum* (L) Kuhn var. *latiusculum* (Desv.) Underw.
Fern, interrupted	*Osmunda claytoniana* L.
Fern, spinulose wood	*Dryopteris spinulosa* (O.F. Muell.) Watt
Hazel, beaked	*Corylus cornuta* Marsh.
Holly, mountain	*Nemopanthus mucronata* (L.) Trel.
Wild-raisin	*Viburnum cassinoides* L.
Winterberry	*Ilex verticillata* (L.) Gray
Rust, white pine blister	*Cronartium ribicola* Fisch.
Weevil, white pine	*Pissodes strobi* Peck