TWENTY YEARS GROWTH OF DEBUDDED RED PINE

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SUMMARY

In 1942 an experiment was begun to determine the possibility of producing knot-free red pine by removing the lateral buds annually until the required knot-free bole length had been produced.

Starting with a 6-year-old red pine plantation, a knot-free 16.5-foot length of bole was produced in 9 years. Ten years later, when the debudded trees had developed normal crowns, the debudded trees averaged 1 inch less in diameter and 6 feet less in height than the control trees. The only apparent advantage in debudding is that clear lumber of a given width can be produced about 20 years earlier than by conventional saw pruning. Poorer quality wood, owing to the presence of compression wood and juvenile core wood, may nullify this advantage of earlier production.

INTRODUCTION

Red pine (*Pinus resinosa* Ait.) is one of the most important lumber-producing species planted in eastern Canada. The price differential of clear over knotty lumber is considerable. Consequently various cultural methods such as pruning, manipulation of spacing, and thinning have been tried in attempts to increase the yields of high-quality lumber. This paper gives the results after the first 20 years of a bud-pruning experiment aimed at producing knot-free butt logs, 16.5 feet long, from planted red pine at the Petawawa Forest Experiment Station.

EXPERIMENTAL PROCEDURE

Following the lead of Krotkevitch in Russia (Bucholtz, 1939), this debudding experiment was initiated in 1942. Two 1/10-acre sample plots were laid out in a 6-year-old pine plantation, which had been planted at a spacing of 6 x 6 feet on somewhat dry, fine to medium, windblown sands.

On one plot all the current lateral buds and all branches above 3.5 feet from the ground were removed at the start of the growing season. The trees on the other plot were left untreated as controls. The current lateral buds on the main stem were removed each spring until 1950 (Figure 1) when most of the trees were 20 feet high, thus producing the desired 16.5-foot knot-free butt section. After 1950 the crowns were allowed to grow normally, and in 1957 the basal branches were removed leaving the upper whorls of branches to sustain the tree.

The heights and diameters of all trees, both treated and control, were measured in 1945 and at 5-year intervals thereafter; the latest measurements were taken in 1960.

RESULTS

Bickerstaff (1946 and 1952) reported on the early results from this study, which may be summarized as follows:

1. Diameter growth of debudded trees was reduced.
2. Clear sections of debudded trees were more cylindrical than corresponding sections of untreated trees.

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3. Mortality during the first 10 years was negligible on both debudded and control plots.
  4. It was possible to obtain a 16-foot knot-free bole length in about 10 years (14 years after planting).
- The 20-year results from this study are presented below.

Diameter

The average diameter of all undamaged trees still alive in 1960 has

FIGURE 1. The debudded stand one year after the debudding was completed.

FIGURE 2. Vertical sections from representative debudded (D) and control (C) trees in 1960. The scale measures from a stump height of one foot.

FIGURE 3. The same stand after the first thinning in 1960. The marked trees are the selected crop trees to be harvested at age 100 years.

Captions for figures on page 348

- FIGURE 1. Growth of *H. pruinatum* in water agar containing: (left) 1/10,000 Acti-dione concentrate; (centre) control, no Acti-dione; (right) 1/1,000,000 Acti-dione.
- FIGURE 2. *Hypoxyylon* canker on *P. trichocarpa*: (left) cuttings dipped in 1/10,000 Acti-dione and allowed to dry gradually in a moist chamber for 20 days after inoculation; (centre) surface sterilized cuttings provided with a continuous supply of water; (right) cuttings dipped in 1/10,000 Acti-dione and provided with a continuous supply of water after inoculation, note—no infection.
- FIGURE 3. Representative rooting of surface sterilized cuttings of *P. trichocarpa* in sterile water for a period of 28 days.
- FIGURE 4. Representative rooting of surface sterilized cuttings of *P. trichocarpa* in extract of bark saprophytes for a period of 28 days. Note the branched roots and absence of injury to the shoot of the left hand cutting which was submerged in extract over the period of the experiment.
- FIGURE 5. Representative excised roots from a surface sterilized cutting in sterile water.
- FIGURE 6. Representative excised roots from a surface sterilized cutting in extract of bark saprophytes.

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FIGURE 1a. P.S.P. 197. A 33-year-old unthinned red pine plantation.

FIGURE 1b. P.S.P. 196. A 33-year-old thinned red pine plantation.

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FIGURE 1c. (Left) Composite photo of P.S.P. 146 (with author).

FIGURE 1d. (Right) One of the six pruned red pine boles in P.S.P. 146.

been summarized by original height classes (Table 1). Debudded trees were still smaller than the controls (Figure 2) but the difference in average diameter was 1.1 inches instead of 1.4 inches as in 1955 (and 1.3 inches in 1950).

TABLE 1
AVERAGE DIAMETER OF CONTROL (C) AND DEBUDDED (D) TREES AT
5-YEAR INTERVALS

Number of trees per plot ¹		1941 Height class (feet)	Average diameter (inches)							
			1945		1950		1955		1960	
C	D		C	D	C	D	C	D	C	D
5	3	3	1.5	1.0	2.9	2.3	3.3	3.0	3.6	3.8
19	15	4	1.9	1.7	3.6	2.6	4.1	3.4	4.5	4.1
42	36	5	2.3	2.0	4.1	2.8	4.9	3.6	5.6	4.5
33	37	6	2.8	2.3	4.6	3.1	5.5	3.8	6.0	4.7
19	9	7	3.0	2.6	4.9	3.3	5.8	4.0	6.4	5.1
118	100	Average	2.5	2.1	4.2	2.9	5.0	3.6	5.6	4.5

¹Damaged trees have not been included.

The difference in diameter increment from 1945 to 1960 between the debudded and control trees is highly significant. However, the average annual diameter increment of the controls has dropped steadily whereas that of the debudded trees remained constant (Table 2). For the past 5 years the periodic increment of the debudded trees was greater than that of the controls.

The decline in diameter growth rate of the controls is due to increasing competition as the tree crowns closed, whereas the crowns of the debudded trees are just beginning to close and thus to bring about a decrease in growth. Periodic thinnings should decrease the competition and thus increase or at least maintain the growth rate of the controls.

TABLE 2
AVERAGE PERIODIC INCREMENT OF CONTROL (C) AND DEBUDDED (D) TREES
FROM 1941 TO 1960

Period	Diameter (inches)		Height (feet)	
	C	D	C	D
1941-45	—	—	8	7
1945-50	1.7	0.8	10	9
1950-55	0.8	0.7	8	4
1955-60	0.6	0.9	8	8

Height

Early development suggested that the debudding had some effect on height growth (Bickerstaff, 1952). In 1960, the average height of the controls was 39 feet whereas that of the debudded trees was only 33 feet (Table 3); this difference is highly significant.

TABLE 3
AVERAGE HEIGHT, BY 1941 HEIGHT CLASSES, OF CONTROL (C) AND
DEBUDDED (D) TREES AT 5-YEAR INTERVALS

Number of trees per plot		1941 Height class (feet)	Average height (feet)							
			1945		1950		1955		1960	
C	D		C	D	C	D	C	D	C	D
5	3	3	10	8	20	17	27	22	33	30
19	15	4	11	10	21	19	29	24	36	33
42	36	5	12	12	23	20	31	25	39	33
33	37	6	14	13	25	21	32	25	40	33
19	9	7	16	15	25	23	33	27	42	35
118	100	Mean	13	12	23	21	31	25	39	33

During the 9-year debudding period, the control trees averaged only 2 feet greater height growth than the treated trees, but in the 5 years after debudding was discontinued average height growth on the control trees was 4 feet greater (Table 2); i.e., the rate of growth of the controls was very nearly maintained while that of the debudded trees dropped by a half. This slowing down followed by resumption of normal height growth 1955 to 1960, is not easy to explain. Perhaps the scanty foliage of a debudded tree was sufficient to sustain near normal leader growth during the treatment period, but could not meet the requirements of both laterals and leader for the first few years after debudding had been stopped. Once several whorls had been formed, the new crown evidently was capable of supporting full growth of the leader and of the laterals of the uppermost whorls as well.

Mortality and Damage

Mortality up to 1950 was negligible on both plots, but during the next 10 years 3 per cent of the debudded trees and 6 per cent of the control trees died. Wind and snow bent 5 per cent of the debudded trees, and these were removed because they were not expected to recover. Since the numbers of stems dropping out of the two stands were about the same, debudding in itself evidently has had no important effect on total mortality; nor has it contributed greatly to stem bending or breakage.

Wood Quality

A representative sample of both the debudded and control trees was analysed by the Forest Products Research Branch of the Department of

Forestry (Hale, 1961). The general results from the analysis of some basic characteristics were as follows:

1. All trees have low specific gravity for red pine.
2. The debudded trees grew slower and had a significantly higher specific gravity than the controls.
3. Compression wood was present in the debudded stems but not in the controls. The presence of this compression wood accounts, in part, for the higher specific gravity of the debudded stems. Compression wood is unsuitable for many technological applications and must be considered as a defect.
4. The cell development of both control and debudded trees appears to be normal for the age of the trees.

The compression wood in the debudded stems may have been caused by wind—a common cause of this defect—which could enter the debudded stand freely and cause much stem movement. Debudding only selected stems, rather than all the stems, should lessen wind within a stand.

Cost of Debudding

The actual costs of debudding were not recorded but they were probably higher than those that would have been incurred by conventional saw pruning. Curtis (1946) reported that debudding costs were higher than those for saw pruning. On the other hand Fox (1957) found that debudding costs less, but in his study fewer years of treatment were required than in the Petawawa study. By extending Fox's data the derived time required per tree for 9 years' treatment amounts to approximately 13 man-minutes. This is considerably more than saw pruning times of 9 to 10½ minutes and 8 to 10 minutes reported by Ralston (1953) and Bramble and Schmidt (1951) respectively.

FUTURE WORK IN THIS STUDY

The diameter growth of the trees on the control plot had slowed owing to increasing competition. If this condition were permitted to continue long, the comparative results of this debudding experiment would be nullified. Consequently both the debudded and control plots will be thinned every 10 years to produce a final stand of 150 trees per acre at age 100. The same number of trees will be carried on each plot.

Potential crop trees (plus an additional 60 trees per acre as insurance) (Figure 3) have been selected and those on the control plot have been saw pruned to a height of 17 feet. The first thinning, made in 1960, reduced the number of trees to 900 per acre; the trees cut were those whose removal would benefit the selected crop trees. Succeeding thinnings will be done similarly with about 25 per cent of the trees then present being removed at each operation.

The height data suggest that these trees are in Site Group I (Horton and Bedell, 1960) and the control trees are expected to be about 90 feet tall and 16 inches in diameter (b.h.) at age 100. The debudded trees should be at least 84 feet tall and 15 inches in diameter if they continue to grow

at about the same rate as the controls. This relative performance seems quite possible, judging by growth rates of the past 5 years.

DISCUSSION

Growing a completely knot-free butt log by annually removing the lateral buds until the tree has reached a height of about 20 feet is easily possible but the question of whether it is economically feasible remains to be answered. Pruning every tree in a plantation by saw does not pay, and similarly it is not economical to debud every tree. But is debudding worthwhile on the basis of the individual tree carried through to maturity?

Comparison of costs between debudding and conventional saw pruning involve a number of factors such as:

1. Rate of height growth

This governs the number of whorls to be removed and, therefore, the number of years in which debudding is required. Slow growth means not only more annual debudding operations, but more in which a ladder is needed to reach the upper portion of the stems. Growth rate does not affect the time of conventional saw pruning as much, although slower-grown trees will take slightly longer to prune (owing to their extra whorls) than will trees with good growth rates.

2. Spacing within the plantation

At the wider spacings the branches are larger which increases the time and therefore the cost of saw pruning whereas the cost of the debudding operations would not be affected.

3. Total volume and value of the final product

Present indications are that saw-pruned trees will be larger and more valuable than debudded trees at maturity. The saw-pruned trees are expected to produce approximately the same volume of clear lumber as the debudded trees, but a greater quantity of lower grade lumber, at maturity (in this case at age 100). This is based on the assumption that the debudded trees will be about 6 feet shorter and 1 inch smaller in diameter than the control trees which have knotty cores of about 6 inches in diameter.

At the moment the chief advantage of debudding seems to be that clear lumber of a given width can thus be produced about 15 to 20 years sooner than by saw-pruning. This advantage may be more than offset by the lower total volume produced, the higher initial cost of debudding, and perhaps the presence of a greater quantity of compression wood. It is too early, however, to predict what the relative growth rates of the trees will be from now to maturity or the relative lumber values when the trees are harvested.

Another factor that might possibly further offset the chief advantage of debudding is downgrading of lumber containing juvenile corewood. This corewood has a greater tendency to warp, shrink, and split when sawn into lumber than mature wood (Rendle, 1958). In the control trees this corewood is within the knotty core whereas in the debudded stem it is in the

knot-free section. As a result the debudded trees will probably yield less high-quality clear lumber than originally expected. In fact the time required to produce lumber of a given width will be increased and may, in the long run, be the same as the time required when saw-pruning.

In conclusion knot-free butt logs can be produced by annually debudding red pine. But owing to the uncertainty of economics, unpredictable growth rates, and the likelihood of the lumber containing quantities of compression wood and juvenile corewood, debudding of red pine may prove to be unprofitable.

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