# TEN-YEAR RESULTS OF EXPERIMENTAL PULPWOOD CUTTING IN IMMATURE BLACK SPRUCE AND BALSAM FIR



by
D. E. Nickerson



FOREST RESEARCH LABORATORY
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The experiments on which this report is based originated through the desire, expressed in the early 1950's, by senior woods department personnel of Price (Nfld.) Pulp and Paper Mills, Ltd. and Bowaters Newfoundland Limited for information on the desirability and the effects of carrying out pulpwood operations in immature merchantable softwood stands. Messrs. B.W. Potts and F.R. Hayward of Price and Messrs. Albert Martin and Cyril Parsons of Bowaters took part in preliminary discussions and personally participated in many aspects of the planning and establishment phases, particularly by arranging for harvesting operations to be carried out by the respective companies. The others have since retired but Mr. Hayward's continuing interest has been of great assistance.

Mr. W.A. Dickson, now Chief Forester of Bowaters but at that time a research officer with the Canadian Forestry Service was Project Chief at time of establishment. Other foresters who made significant contributions were: Messrs. Ron Pond in charge of Bowater harvesting operations, D.L. Armstrong (C.F.S.) field chief for establishment of Price experiment, and R.S. van Nostrand (C.F.S.) who supervised the 10-year remeasurements of both experiments and whose advice and assistance have been helpful in preparing this report.

# TEN-YEAR RESULTS OF EXPERIMENTAL PULPWOOD CUTTING

# IN IMMATURE BLACK SPRUCE AND BALSAM FIR

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## INTRODUCTION

Two large-scale cutting experiments were established* in 1954 and 1955 on limits of Newfoundland's two pulp and paper companies. Project NF-21 in black spruce is located near West Branch Lake, south of Badger on Crown land under license to Price Newfoundland Ltd. Project NF-22 in balsam fir at Snug Harbour on the west side of Deer Lake in western Newfoundland is located on Bowater freehold land.

The purpose of the projects was to investigate the desirability of entering young merchantable stands of black spruce (NF-21) and balsam fir (NF-22) to clearcut or to remove selected trees with a view to clearcutting 20 years later. The premise on which partial cutting was based was that if at the end of 20 years stands so cut contained merchantable volumes equivalent to stands on uncut control blocks the wood removed by partial cutting could be regarded as a bonus yield.

### Nature of Experimental Stands

Both experiments were located in vigorous immature stands averaging approximately 18 cords (rough cords of 85 cu. ft.) per acre. At the time when the experiments were planned routine clear-cutting operations in old-growth stands on company limits were yielding an average of 13 to 15 cords per acre so despite the fact that these stands were considered "young" for harvesting they contained more wood then current operational averages. The average d.b.h. of merchantable stems in both stands was 5 inches for trees 3.6 inches at b.h. and larger. There were very few crop trees in excess of 9 inches at b.h. in either stand. Heights of crop trees ranged from 30 to 50 feet.

Black spruce was the predominant species at West Branch Lake (NF-21) and balsam fir was predominant at Snug Harbour (NF-22). White birch, fir, trembling aspen, and white spruce occurred as minor species at West Branch Lake. White birch and white spruce were present at Snug Harbour. Larch occurred as scattered trees in both locations. Both stands were characterized by an abundance of stems in the 1-3 inch d.b.h. class, approximately 1000 black spruce per acre on NF-21 and 1500 balsam fir on NF-22. There were somewhat fewer stems of merchantable size at West Branch than at Snug Harbour, 701 as opposed to 772 per acre on partial-cut blocks and 572 as opposed to 636 on controls.

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* W.A. Dickson, 1957, Establishment Report Large-Scale Cutting Experiment No. 1 (Project NF-21), Forestry Branch, Nfld. District, Unpub. manuscript.

W.A. Dickson, 1957, Establishment Report Large-Scale Cutting Experiment No. 2 (Project NF-22), Forestry Branch, Nfld. District, Unpub. manuscript.

The black spruce stand at West Branch originated following fire and except for harvesting of a few residual white pine has been undisturbed. Sixty years is used as total age for calculating mean annual increments as of the start of the experiment. This age was determined by adding 10 years to age (to the nearest 10 years) at b.h. of crop trees.

The balsam fir stand at Snug Harbour has a more varied history. It resulted from opening up of the original stand early in the century by natural decadence, believed to have been accompanied by insect attack. Residual old-growth softwood stems were removed between 1920 and 1933. Increment borings indicate a variation in average age between individual cutting blocks of up to 10 years. For the purposes of this analysis a mean age at b.h. of 40 years is used and age used in calculating mean annual increment at the start of the experiment is 50.

The soil at West Branch Lake consists of well-drained reddish-brown sandy loam under 2 to 4 inches of leached greyish material. Rocks and boulders abound. Surface vegetation is composed of an unbroken layer of feathermosses over 2 to 4 inches of undecomposed humus. The site is typical of the better upland black spruce sites in central Newfoundland. The Snug Harbour site is a bottom-land slope adjacent to Deer Lake. The soil is a rich clay-loam. Surface vegetation consists of feathermosses except under particularly dense parts of the stand where the surface is raw needles. Undecomposed humus is 2 to 4 inches in depth.

## Nature of Experiments

Each experiment consists of 15 square 10-acre blocks located so as to avoid insofar as possible uncharacteristic conditions (poorly drained areas, etc.). Treatments were assigned to these blocks at random. These were:

| | |
|---|---|
| (1) Uncut control | 3 blocks |
| (2) Clearcut first year | 3 blocks |
| (3) Partial cut first year | 3 blocks |
| (4) Clearcut second year | 3 blocks |
| (5) Partial cut second year | 3 blocks |

Clearcutting meant removing all softwood stems which would provide at least one 4-foot pulpwood bolt to a 3-inch top, cutting and piling wood along strip roads for winter hauling.

The partial cutting method called for 10-foot extraction roads to be cleared at 100-foot intervals and for 40 percent of the commercial volume on the intervening 90-foot strips to be harvested by cutting trees marked for removal. For a gross area, such as a 10-acre block, this would theoretically mean that 10 percent of the original commercial volume would be removed as roadwood and 36 percent of the original commercial volume as marked trees. The total commercial volume removed would be 46 percent of the original volume and after cutting the block still would contain 54 percent of its original total commercial volume.

The marking system was designed to produce a reasonable yield without exposing residual stands to risk of serious wind damage. A relatively flat-topped stand in which there would be no open spaces large enough to invite wind damage was sought. Marking was concentrated on the largest stems; care was taken not to create openings; but most important was the serious endeavour made to maintain the percentage to be removed, 40 percent of commercial volume, uniform in each part of each strip. If all trees were relatively small part way along a strip a sufficient number of the largest of these were marked for removal to provide the required volume percentage. If further along the same 90-foot strip the trees were larger sufficient of the largest of these were marked to provide the required 40 percent for that location.

## Measurements

The principal measurements to date consist of:

(1) 100 percent tally of all stems of all species in 1-in. d.b.h. classes on all blocks prior to cutting.

(2) Similar tally on a system of 1/5 acre stand variation plots located within each block.

(3) After-cut tally on all blocks on which cutting had taken place (similar to 1 and 2 above).

(4) Re-tally of all blocks 10-12 years later similar to (1) and (2) above except that 1 to 3 inch stems were not tallied and clearcut blocks were omitted.

(5) Collection of diameter-height information at time of establishment and at later remeasurement.

(6) Collection of information on age.

(7) Regeneration survey at start and at latest remeasurement.

## Present Analysis

The present analysis is confined to partial-cut and (uncut) control blocks. It is also confined to two species, spruce and fir, and to trees 3.6 inches and up. Volumes are commercial volumes as calculated from the attached tables. No allowance is made for cull. (Very little cull was encountered in cutting operations in these stands and it is still assumed to be inconsequential).

Apart from information necessary for volume-table revision and age determination the analysis is based on successive 100 percent tallies of 10-acre blocks.

Due to the fact that cutting extended over a 2-year period and that remeasurements were carried out in 1965 at West Branch and 1966 at Snug Harbour a problem arose in presenting results in a form which would allow ready comparison. The actual measurement interval for various groups of blocks ranged from 10 to 12 years while calendar year of the final remeasurement varied between experiments. The approach used here has been to reduce latest volumes and stems per acre by simple proportion to assumed values 10-years after the earlier measurement.

Due to deficiencies in the data three partial-cut blocks at Snug Harbour were omitted from the analysis.

The process has been to set forth quantitative results in a basic table, Table 1. This is followed by a series of tables, all derived from Table 1, which allow the results to be viewed in varying perspectives.

The cunit, 100 cu. ft. of solid wood, has been used as the unit of volumetric measurement except in tables 3 and 5 where it has been found more convenient to use cubic feet.

## Results

The results considered here are summarized in six tables. They are:

Table 1. Yields per Acre in Cunits of Solid Wood and Numbers of Stems (corrected to a 10-year. base) for Spruce and Fir 3.6 in. and Larger at Breast Height.

Table 2. Analysis at 10-year Increment on a Per-Acre Basis by Cunits and Number of Stems

Table 3. Average Volumes in Cubic Feet and D.B.H. in Inches of Spruce and Fir Trees 3.6 Inches at D.B.H. and Larger.

Table 4. 10-Year Net Increment on Residuals or Originals Expressed as Percentages of Volumes at Start of Period.

Table 5. Yield and Increment Summary - Per Acre Per Year by Volume in Cubic Feet and Weight (Air-Dry) in 1000's of Pounds.

Table 6. Local Merchantable Volume Tables 4-Foot Wood, Stump Height 1 Foot, Top Diameter 3 Inches.

Table 1. Yields per Acre in Cunits of Solid Wood and Numbers of Stems (corrected to a 10-yr. base) for Spruce and Fir 3.6 in. and Larger at Breast Height.

| | NF-21 Vol. | (Price)* Stems | NF-22 Vol. | (Bowaters)** Stems |
|---|---|---|---|---|
| Partial Cut | | | | |
| Before Cutting | 15.7 | 701 | 19.3 | 772 |
| After Cutting | 8.4 | 449 | 10.0 | 394 |
| Harvested | 7.3 | 252 | 9.3 | 378 |
| 10-yr. Net Increment | 5.5 | 115 | 9.5 | 259 |
| Net Yield to End of 10 yrs. | 21.2 | 816 | 28.8 | 1031 |
| Living at End of 10 yrs. | 13.9 | 564 | 19.5 | 653 |
| 10-yr. Mortality | 0.2 | 13 | 0.7 | 19 |
| Uncut Controls | | | | |
| Initial | 13.9 | 636 | 13.1 | 572 |
| 10-yr. Net Increment | 6.5 | 76 | 12.4 | 322 |
| Living at End of 10 yrs. | 20.4 | 712 | 25.5 | 894 |
| 10-yr. Mortality | 0.3 | 7 | 0.5 | 10 |

*More than 90 percent black spruce

**More than 90 percent balsam fir

Table 2. Analysis at 10-year Increment on a Per-Acre Basis by Cunits and Number of Stems

| | NF-21 (Price) Cunits | NF-21 (Price) Stems | NF-22 (Bowaters) Cunits | NF-22 (Bowaters) Stems |
|---|---|---|---|---|
| **Partial Cut** | | | | |
| Gross Increment | 5.7 | 128 | 10.2 | 278 |
| G.I. on Residuals | 4.6 | - | 5.2 | - |
| Mortality | 0.2 | 13 | 0.7 | 19 |
| N.I. on Residuals | 4.4 | -13 | 4.5 | -19 |
| Ingrowth | 1.1 | 128 | 5.0 | 278 |
| Net Increment | 5.5 | 115 | 9.5 | 259 |
| **Uncut Controls** | | | | |
| Gross Increment | 6.8 | 83 | 12.9 | 332 |
| G.I. on Residuals | 6.0 | - | 6.9 | - |
| Mortality | 0.3 | 7 | 0.5 | 10 |
| N.I. on Residuals | 5.7 | -7 | 6.4 | -10 |
| Ingrowth | 0.8 | 83 | 6.0 | 332 |
| Net Increment | 6.5 | 76 | 12.4 | 322 |

Table 3. Average Volumes in Cubic Feet and D.B.H. in Inches of Spruce and Fir Trees 3.6 Inches at D.B.H. and Larger.

| | NF-21 (Price) | | NF-22 (Bowaters) | |
|---|---|---|---|---|
| | Vol. | D.B.H. | Vol. | D.B.H. |
| Partial Cut | | | | |
| Before Cutting | 2.2 | 5.3 | 2.5 | 5.1 |
| After Cutting | 1.9 | 5.1 | 2.5 | 5.1 |
| Harvested | 2.9 | 5.7 | 2.5 | 5.1 |
| 10-yr. Living Residuals | 2.9 | 5.7 | 3.9 | 5.8 |
| 10-yr. All Living | 2.5 | 5.4 | 3.0 | 5.3 |
| 10-yr. Mortality | 1.5 | 4.7 | 3.7 | 5.7 |
| Uncut Controls | | | | |
| Initial | 2.2 | 5.3 | 2.3 | 4.9 |
| 10-yr. Living Originals | 3.1 | 6.0 | 3.5 | 5.6 |
| 10-yr. Living | 2.9 | 5.7 | 2.9 | 5.1 |
| 10-yr. Mortality | 4.3 | 6.8 | 5.0 | 6.5 |

Table 4

A — 10-Year Net Increment on Residuals or Originals Expressed as Percentages of Volumes at Start of Period.

| | Partial Cuts | Uncut Controls |
|---|---|---|
| NF-21 (West Branch) | 52 | 41 |
| NF-22 (Snug Harbour) | 45 | 49 |

B — 10-Year Net Increment Including Ingrowth Expressed as Percentages of Volumes at Start of Period.

| | Partial Cuts | Uncut Controls |
|---|---|---|
| NF-21 | 66 | 47 |
| NF-22 | 95 | 95 |

Table 5. Yield and Increment Summary — Per Acre Per Year by Volume in Cubic Feet and Weight (Air-Dry) in 1000's of Pounds

| | NF-21 (Price) (Initial age 60 yrs.) | | NF-22 (Bowaters) (Initial age 50 yrs.) | |
|---|---|---|---|---|
| | Vol. | Weight | Vol. | Weight |
| Partial Cut | | | | |
| M.A.I. Prior to Cutting | 26 | 0.84 | 39 | 0.97 |
| C.A.I. Next 10 years | 55 | 1.76 | 95 | 2.37 |
| M.A.I. at End of 10 years | 30 | 0.96 | 48 | 1.20 |
| Uncut Controls | | | | |
| M.A.I. Initial | 23 | 0.74 | 26 | 0.65 |
| C.A.I. Next 10 years | 65 | 2.08 | 124 | 3.10 |
| M.A.I. at End of 10 years | 29 | 0.93 | 42 | 1.04 |

N.B. Total ages assigned above were obtained by adding 10 years to average ages of crop trees at breast height as determined from increment borings. Weights have been calculated using 24 lbs. per cu. ft. (air-dry) for fir and 33 lbs. for black spruce (general averages from Canadian Woods, 1951, Forestry Branch, Ottawa) assuming that 10 percent of the yield throughout on each experiment can be attributed to the minor species, spruce or fir as the case may be.

## Table 6

### Local Merchantable Volume Tables

4-Foot Wood, Stump Height 1 Foot, Top Diameter 3 Inches

| DBH | West Branch - NF-21 | | | | | | | | Snug Harbour - NF-22 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1955 | | | | 1965 | | | | 1955 | | | | 1966 | | | |
| | Black Spruce | | Balsam Fir | | Black Spruce | | Balsam Fir | | Black Spruce | | Balsam Fir | | Black Spruce | | Balsam Fir | |
| | Ht. in ft. | Vol. Cu.ft | Ht. in ft. | Vol. Cu ft | Ht. in ft | Vol. Cu ft. | Ht. in ft. | Vol. Cu ft. | Ht. in ft | Vol. Cu ft. | Ht. in ft. | Vol. Cu ft. | Ht. in ft. | Vol. Cu ft. | Ht. in ft. | Vol. Cu ft. |
| 4 | 33.3 | 0.9 | 28.5 | 1.3 | 34.0 | 0.9 | 36.0 | 1.6 | 32.4 | 0.9 | 32.4 | 1.5 | 40.0 | 1.0 | 40.0 | 1.8 |
| 5 | 37.0 | 1.8 | 34.6 | 2.2 | 39.2 | 1.9 | 41.5 | 2.6 | 39.5 | 1.9 | 39.5 | 2.4 | 43.5 | 2.1 | 43.5 | 2.7 |
| 6 | 40.8 | 3.1 | 40.4 | 3.5 | 43.5 | 3.3 | 45.8 | 4.0 | 43.3 | 3.2 | 43.3 | 3.6 | 47.0 | 3.6 | 47.0 | 4.1 |
| 7 | 44.3 | 4.7 | 45.5 | 5.2 | 47.2 | 5.1 | 49.4 | 5.6 | 46.1 | 4.9 | 46.1 | 5.2 | 51.0 | 5.5 | 51.0 | 5.8 |
| 8 | 47.3 | 6.7 | 50.0 | 7.2 | 50.3 | 7.1 | 52.7 | 7.6 | 47.3 | 7.1 | 47.3 | 6.9 | 53.0 | 7.6 | 53.0 | 7.7 |
| 9 | 50.0 | 9.0 | 52.7 | 9.3 | 53.1 | 9.5 | 55.4 | 9.9 | 50.5 | 9.3 | 50.5 | 9.2 | 57.0 | 10.3 | 57.0 | 10.2 |
| 10 | 51.7 | 11.4 | 54.0 | 11.5 | 55.7 | 12.3 | 58.0 | 12.5 | 56.5 | 12.2 | 56.5 | 11.8 | 60.5 | 13.7 | 60.5 | 13.3 |
| 11 | 52.5 | 13.8 | 55.0 | 14.0 | 58.0 | 15.4 | 60.5 | 15.6 | 57.3 | 15.1 | 52.3 | 14.6 | 63.0 | 17.1 | 63.0 | 16.2 |
| *12 | 53.3 | 16.5 | 55.5 | 16.4 | 60.2 | 19.0 | 62.5 | 18.8 | 59.0 | 18.5 | 59.0 | 17.6 | 65.0 | 20.2 | 65.0 | 19.6 |
| 13 | 54.0 | 19.5 | 56.0 | 19.0 | 62.2 | 22.6 | 64.0 | 22.2 | | | 60.0 | 20.6 | 66.0 | 25.5 | | |
| 14 | 54.6 | 22.8 | 56.2 | 21.9 | 64.0 | 26.7 | 65.3 | 26.2 | | | | | | | | |
| 15 | 55.0 | 26.1 | 56.5 | 24.7 | 65.2 | 31.0 | 66.5 | 30.0 | | | | | | | | |
| 16 | 55.5 | 29.5 | 56.7 | 27.8 | 66.0 | 35.5 | 67.2 | 34.3 | | | | | | | | |
| 17 | 55.8 | 33.4 | 56.9 | 31.0 | 67.0 | 40.8 | 68.0 | 39.6 | | | | | | | | |
| 18 | 56.0 | 37.2 | 57.0 | 34.3 | 67.3 | 46.0 | 68.4 | 43.3 | | | | | | | | |
| 19 | | | | | 67.7 | 51.8 | 68.8 | 48.5 | | | | | | | | |
| 20 | | | | | 67.8 | 57.5 | 69.0 | 53.8 | | | | | | | | |

* Height values below line derived by extrapolation.

N.B. The above tables have been derived from standard volume tables contained in growth trends in spruce and fir stands in central Newfoundland by R.S. van Nostrand, Dept. of Forestry Publication No. 1063, 1964 by applying local diameter/height relationships.

## Discussion

### Initial Volumes

It will be seen from Table 1 that despite random assignment of treatments to blocks the initial volume on uncut control blocks in both experiments was appreciably less than on blocks subjected to partial cutting. This difference, 1.8 cunits per acre on NF-21 and 6.2 cunits per acre on NF-22, contribute to the slight advantage in net yield at the end of 10 years of the partial cuts over the controls.

### Harvested Volumes

The values given for harvested volume in Table 1 were obtained by subtracting standing volume after cutting from standing volume before. Theoretically 46 percent of standing volume would have been removed. Percentages calculated from Table 1 fall within 2 percentage points of this value. While undue emphasis should not be placed on this remarkably close agreement it suggests that these operations were carried out in very close conformity to the plan and that the data used here provides a sound base for calculations which follow.

### Mortality Including Windfall

The general lack of mortality, only 1 to 2 trees per acre per year, on both experiments indicates that mortality of stems of merchantable size due to internal competition for growing space is not yet a serious factor. The low values for mortality, which include windfall, indicate that the partial-cutting method used was exceptionally successful in respect to one of its objectives. The method was designed to reduce wind damage to residual stands to a minimum and it did.

### Trees of Average Volume

Changes in average volume and d.b.h. of merchantable stems are shown in Table 3. These changes were relatively small. The average tree on partial-cut in NF-21 was 5.3 in. at d.b.h. prior to cutting and ten years after cutting was 5.4. On uncut controls (NF-21) the increase was from 5.3 to 5.7. On NF-22 corresponding values were 5.1 and 5.3, and 4.9 and 5.1. The latter values in each case reflect the inclusion of ingrowth. Diameter increment on the average residual (or original on controls) was 0.6 or 0.7 inches in all four cases for the 10-year period with no appreciable difference evident due either to species or stand treatment.

10-Year Increments

Increments listed in Table 1 and 2 are based on gross treatment area. They contain no allowance for the fact that approximately 10 percent of the partial-cut blocks was in reality clearcut for roads. Extremely high 10-year net increment values for NF-22 were caused by ingrowth (Table 2). Balsam fir is known to be tolerant of shade. The number of stems per acre 3.6 inches and up was far from excessive and it is not surprising that many stems grew into the 4-inch d.b.h. class.

Increment in Percent

A feature of both experimental stands was that they appeared to be dense. The balsam fir stands in NF-22 appeared to be particularly so. Total stems per acre of all species in NF-21, 1-inch and up, averaged slightly less than 2000 and in NF-22 somewhat more. Yet original stems on uncut controls increased in net volume in a 10-year period by 41 and 49 percent respectively (Table 4). This is a very creditable rate of increment. It indicates the danger of assuming that because a young commercial stand on a good site appears to be dense commercial increment is necessarily suffering. It suggests that if the number of stems of commercial size is not excessive and the site is neither excessively dry nor poor in nutrients large numbers of 1-3 in. trees can be tolerated.

Attention is directed to the fact that percentage increment on residuals on partial cut in NF-21 exceeded increment on originals on control blocks on the same area for a 10-year period. This indicates a definite response by black spruce to opening up of the stands. When it is considered that the largest and presumably the fastest-growing stems were removed the response by the remaining residuals of merchantable size is excellent.

In terms of net percentage increment (including ingrowth) partial-cut blocks in NF-21 are gaining on the controls, 66 versus 47, but in NF-22 both increased in commercial volume by 95 percent during the 10-year period.

Longterm Yields

During the 10-year period under consideration the mean annual increment on partial cut in black spruce stands on NF-21 at West Branch Lake increased from 26 to 30 cu. ft. per acre per year (Table 5). The increase on uncut control in the same experiment was from 23 to 29 cu. ft. per acre per year. The apparent advantage of the partial cut up to the end of the 10-year period must be attributed to higher initial volume. During the period m.a.i. actually increased by 6 cu. ft. per acre per year on the controls as opposed to 4 cu. ft. per acre per year on partial cut.

Due to more ingrowth at Snug Harbour than at West Branch Lake corresponding values for the balsam fir experiment (NF-22) are considerably higher. Mean annual increment on partial-cut blocks at Snug Harbour increased from 39 to 48 cu. ft. per acre per year in the 10-year period and on the uncut controls from 26 to 42. Here again the absolute values reflect initial volumes. Mean annual increment increased by 9 cu. ft. per acre per year on the partial cut as opposed to 16 on the controls.

Approximations of m.a.i. in terms of weight of dry wood fibre, Table 5, narrow the gap between yields from black spruce stands at West Branch Lake and balsam fir stands at Snug Harbour very considerably. Apparently the former produced more than 900 lbs. per acre per year to age 70 and the latter more than 1000 to age 60.

The potential yield advantages or disadvantages of partial cutting have been obscured in these experiments by the fact that uncut controls in both cases contained appreciably less volume per acre at the start. Considering that the largest and fastest-growing stems were removed, performance on the partial-cut blocks has been excellent. However, in terms of standing volume the control blocks have gone ahead faster in the 10-year period than the partial cut. It is still possible that the standing volume eventually will equal that on the controls but it is evident that this is unlikely to take place by the end of 20 years.

The marked increase in m.a.i. in both experiments in the 10-year period under review is the most interesting result thus far. Even if immediate stand replacement from regeneration and advance growth can be expected following clearcutting of these sites (as has been indicated by examination of clear-cut blocks) the use of a 60-year rather than a 70-year cutting cycle at West Branch and of a 50-year cutting cycle rather than a 60-year rotation cycle at Snug Harbour would reduce long-term yields very appreciably on a per acre per year basis.

Far from indicating that immature merchantable stands such as these should be clearcut so as to allow a new crop to get started the results obtained here indicate that a serious loss in limit productivity would be incurred by clearcutting such stands when their rate of wood production is increasing rapidly.

At the end of the 20-year period, when the stands at West Branch and Snug Harbour are respectively 80 and 70 years in total age and the clearcut blocks can be realistically assessed as to their prospects a better appraisal can be made of the stage at which similar stands on similar sites should be harvested. Nothing in the results to date indicates that it should be less than the ages mentioned above.

In the case of black spruce at West Branch Lake it could be more unless the current-increment rate inexplicably slacks off. Since balsam fir is a particularly disaster-prone species decisions as to the advisability of holding stands similar to those at Snug Harbour in excess of 70 years of total age in expectation of a further increase in m.a.i. will undoubtedly be guided by consideration of the risk involved, particularly from insect attack.

## Conclusions

It is concluded from these experiments that:

(1) The partial-cutting system used in both experiments was an outstanding success insofar as protection of the residual stands of black spruce and balsam fir from wind damage was concerned.

(2) Neither stand was sufficiently dense in respect to crop-tree density to adversely affect net increment.

(3) In order to obtain full yield advantage from partial cutting such as carried out here it would probably be necessary to delay the final clearcut beyond the age likely to be acceptable to industry.

(4) Clearcutting of stands similar to the black spruce stands at West Branch Lake on a 60 instead of a 70-year rotation; and similar to fir stands at Snug Harbour on a 50 instead of a 60-year rotation, would result in accepting a reduction of the order of 20 and 40 percent respectively from such sites in mean annual increment.

(5) Both experiments should be maintained until the 20-year remeasurement can be carried out at which time they will produce additional valuable information on stand behaviour and desirable guidance as to rotation ages.